THURSDAY, DECEMBER 23, 1897.

THE GROWTH OF GEOLOGICAL IDEAS.

The Founders of Geology. By Sir Archibald Geikie. Pp. x + 297. (London: Macmillan and Co., Ltd., 1897.)

THE truths of science cannot be more impressively taught than by a sketch of the process by which the knowledge has been arrived at, and in no way can that history be more forcibly conveyed than in the biographies of those pioneers who first interpreted the phenomena for us. We may have wondered why the truth was not sooner grasped, but by this method of treating the subject we see what imperfection of evidence or prejudice stood in the way, and learn to appreciate the true spirit of original research which eventually rises above and overcomes all difficulties.

Sir Archibald Geikie has given a sketch of the founders of geology in his, now happily well-known, lucid style. It is necessarily only a selection, and accident or design has led him to make such a selection of points in the development of the subject as has enabled him to write what may be called an "appreciation" of the French school of geologists, and to dwell very fully on the work of some of them whose claims to recognition have hitherto been too much overlooked.

In the earlier stages of research all those who studied the composition of the earth's crust were called mineralogists, and any stony fragments which they dug out of the earth were their fossils. When men began to distinguish between bodies of organic and inorganic origin, they spoke of the pieces of rock and other mineral matter as *native* fossils, considering them as part of the original mass, while they called the remains of plants and animals *extraneous* fossils. It was only in comparatively recent times that the word fossil was applied exclusively to the remains of organisms. When the older writers speculated upon the manner in which the earth's crust had been brought into its present condition, they entitled their results "theories of the earth," which corresponded generally to our modern works on the principles of geology. Though they too often generalised on insufficient data, or wrested their judgment to support an early-formed opinion, they all pretended that their theories were founded on the study of nature; but we find many a good observation and sound inference buried under such a load of bad reasoning, and accompanied by such a cloud of foolish observations, that the writer's credit as a witness was destroyed, and even what was good in him lost sight of.

Our author passes with very brief notice over all the writers earlier than the eighteenth century, and devotes the greater part of his first lecture to a sketch of the work of Guettard: in a few clever touches he brings before us the personality of that remarkable man. Guettard first put into practice the proposal made by Lister in 1683, and constructed a map on which he showed the general surface distribution of the various kinds of rock as they occurred in broad belts in and around the Paris Basin, and even marked on it the places where he had found fossils. Later on, when a good topographical map of France had been produced, he indicated on it the characters of the rock over a very large area, completing the mineralogical survey of no fewer than sixteen sheets of the map. This was a work of great labour, and one involving very close observation, especially as he does not seem to have had any clear idea of the sequence of formations or of geological structure to guide him. Guettard was the first to recognise the ancient volcanoes of Auvergne, and deserves great credit for his able memoir on the meaning of the occurrence of the remains of shells and other organisms in the rocks. But the battle had long been raging between those who maintained that the fossils were mere *lusus naturæ*, and those who held that they represented plants and animals which once lived under conditions analogous to those of recent times, and were buried, as are dead organisms, in the mud and sand of to-day. In this long controversy many Italian and English geologists did good service, notably Agostino Scilla and Dr. John Woodward, who combated especially the erroneous views of Dr. Elie Camerarius; and although their work was hampered by the attempt to accommodate all their explanations to the received interpretation of the Scriptural account of the deluge, still the search for facts to support their theories helped on the work by calling attention to phenomena which might otherwise have long passed unobserved.

In his second lecture our author gives a sketch of the life and work of Desmarest. He tells us of the difficulties and struggles of his early life; of his official work in connection with the efforts made by the French Government in the middle of the last century to develop the industries of the country; and of the influence which the eloquent writings of Buffon had upon him. Desmarest was struck by the correspondence between the opposite cliffs of France and England which had already been pointed out by Guettard, and still earlier by Verstegan. Supporting by biological evidence the idea thus suggested, Desmarest arrived at the conclusion that the channel which now separated them had been cut by the currents of the sea.

His official duties necessitated much travel, but in the intervals of leisure he revisited and more closely examined localities which suggested subjects for further research. In this way he was led to study the origin of basalt, which had been a fruitful theme of controversy for many a long year. He noticed the prismatic structure of the basalts of Auvergne, and recognised them as ancient lavas, and, from descriptions of the general appearance of the columnar rocks of the Giant's Causeway, and an examination of hand specimens, he inferred that they were the same.

He explained the origin of valleys by referring them to the action of the streams which flow in them. This view had evidently been present to the mind of Avicenna, who in the tenth century maintained that mountains were made to stand out by the excavation of the valleys between them, while our great naturalist Ray dwelt upon the operation of streams in the degradation of the land, pointing out that the land must necessarily be eventually reduced below sea level by such agencies.

We are told how from an examination of volcanic phenomena, and in the attempt to correlate them, Desmarest was led to generalise upon the relation of

the volcanic to the sedimentary rocks. He also constructed a map which, however, was not published till after his death. He has left many published works which attest his power, his accuracy of observation, and his judgment.

We have, then, an interesting account of the circumstances which led to the systematic exploration of Russia and the part played in it by Pallas, who, among other important observations, clearly recognised a geological sequence in passing from the centre to the outside of a mountain chain.

The rise of the modern spirit of mountaineering is dated from the time of de Saussure, who described so well the geological structure of the Alps, and whose sections of violently folded rocks anticipated so much of the recent work on that region, and whose experiments on the reduction of granite and basalt to a glassy rock by fusion and rapid cooling marked the commencement of experimental geology.

Our author then traces the development of the doctrine of the geological sequence of rocks as distinguished by their lithological character, towards which much had already been done, especially by the Wernerian school, and also the order of their formation as indicated by the succession of organic life buried in or associated with them, and differing in character at different periods of the world's history. The controversy as to the true nature of fossils, which has been referred to above, shows that importance had long been attached to them as a means of interpreting the history of the earth.

We have in the third lecture an account of Werner, the eponymous hero of a theory and a time. The great controversy between the Neptunists and the Vulcanists set men to search for facts in support of their respective views; and though a wrong working hypothesis may often have coloured the vision and warped the judgment, still the indications offered helped other less prejudiced men along lines where inquiry was fruitful. The Wernerian saw basalts interstratified with fossiliferous rocks, and apparently forming one member of a fossiliferous series, while others traced lava-flows with columnar structure from the crater to the sea, and saw how they might rest on ancient sediments and be themselves covered by newer deposits. Werner was wrong about his basalt, but he had introduced a greater care in investigation and a greater precision of description, and, above all, had so insisted upon the doctrine of geological succession that he placed geology upon a sounder basis than it had hitherto ever occupied.

Von Buch did much to free the scientific world from the tyranny of an uncompromising Neptunism by his demonstration of the constant occurrence of earth-movements down to quite recent times, as well as by many other independent researches recorded in numerous memoirs, and embodied in a large geological map of Germany.

If we give de Saussure credit for originating experimental geology, we must give Hutton a foremost place among those who insisted upon the importance of observation in the field. He was a man of wide interests and varied attainments. He realised the importance of Geology to Agriculture, and published works on "The Principles of Knowledge" and "The Progress of Reason from Sense to Science and Philosophy," this last title reminding us of Agostino Scilla's "La vana Speculazione disingannata dal Senso." The aims of both writers were the same, though Hutton got nearer the mark than his predecessor. In tracing the history of an idea, how often we find that the man who gave it to the world, in what we may call an available form, was not the man with whom it really originated. Take, for instance, the view that the action of heat in fusing material is directly influenced by the amount of pressure to which the body is subjected. This is quoted now with references to Sir James Hall, to Fairbairn and Hopkins, and others. But it was one of Hutton's fundamental doctrines, and Hutton got it from his friend Dr. Black, a sound chemist and shrewd experimentalist.

Hutton's first principle was that "no powers are to be employed that are not natural to the globe, no action to be admitted of except those of which we know the principle, and no extraordinary events to be alleged in order to explain a common appearance."

There are many men of note in our day who, going with the swing of the pendulum, as it were, believe in the greater intensity of the operations of nature in past ages, and still within the periods of which we have records in the sedimentary rocks. The phenomena which suggest this view may be reconciled to the strictest uniformitarianism by the doctrine that local catastrophic action is not inconsistent with continuity of causation.

Several distinguished French geologists, about the end of the last and the beginning of the present century, insisted upon the doctrine of stratigraphical sequence as fundamental, and this was soon found to involve the opinion that there was a definite order of succession among organic remains also. In England, while Giraud Soulavie was still a child, and before Cuvier or Brongniart were born, John Michell, Woodwardian Professor of Geology in the University of Cambridge, gave a clear account of the stratified arrangement of the rocks of England, and by his illustrations showed that he understood the principles of geological structure. "Let a number of leaves of paper," said he, "of several different sorts or colours, be pasted upon one another; then, bending them up into a ridge in the middle, conceive them to be reduced again to a level surface, by a plane so passing through them as to cut off all the part that has been raised. Let the middle row be again raised a little, and this will be a good general representation of most, if not all, large tracts of mountainous countries, together with the parts adjacent, throughout the whole world. From this formation of the earth it will follow that we ought to meet with the same kinds of earths, stones and minerals, appearing at the surface in long narrow slips, and lying parallel to the greatest rise of any long ridge of mountains; and so, in fact, we find them."

Then came William Smith, who based all his classifications on the "strata identified by their organic fossils." Sedgwick, who in early life had been the companion of Smith in some of his excursions in the north of England, was so impressed by the importance of the methods of geological research employed by Smith, that he spoke of him on one occasion before the Geological Society as "the Father of English Geology."

The next and last lecture brings us down to recent times, and the men whom many of us knew. In it we are told of the establishment of the Cambrian, Silurian and Devonian systems by Sedgwick and Murchison; of the discovery that glacial ice once gathered on the mountains of the British Isles; of the coordination of the wisdom of many observers by Lyell and Darwin in the enunciation of the great laws which guide the development of the organic and inorganic world; of the practical application by Nicol and Sorby of chemical and microscopic analysis to the identification of the minerals which make up the rocks, and often to the detection of their mode of aggregation.

The old controversy between Sedgwick and Murchison is introduced with a very skilful relative depreciation of Sedgwick; but perhaps the last has not been heard of that question, and it may yet be acknowledged that whereas the Arenig, Bala, and May Hill series were first clearly defined by Sedgwick, and placed in their true relative positions ("Life and Letters of Sedgwick," vol. i. 529-531; vol. ii. 510-563), the Llandeilo and Caradoc series were placed in their wrong order, and had the wrong fossils assigned to them in the "Silurian System" of Murchison, while the May Hill series was then unrecognised by him. Sir Archibald Geikie very fairly says that the middle disputed series must be either Upper Cambrian or Lower Silurian, and is unwilling to admit the new term Ordovician proposed for it.

Geologists owe a debt of gratitude to Mrs. George Huntington Williams, who founded the lectureship in memory of her distinguished and much lamented husband, the late Professor of Geology in the Johns Hopkins University. They will also accord their thanks to those who selected the first lecturer, and to him for his choice of a subject. T. MCKENNY HUGHES.

THE TWO BONDS.

Memorials of William Cranch Bond and George Phillips Bond. By Edward S. Holden. Pp. 296. (New York: Lemcke and Buechner, 1897.)

IN these days when one is rather inclined to forget who were the pioneers of astronomy in different countries, it is interesting to be able to obtain a volume in which are described the lives, the difficulties to be surmounted, and the success attained by those who have been in these critical positions. The two Bonds—William Cranch and George Phillips, father and son—may be regarded as the first important contributors towards the early history of astronomy in America; and as they were the first two directors of the now well-famed Harvard College Observatory, the earliest founded of any college observatory in the United States, an account of their lives and work is very welcome.

The present volume purposes to afford such information, and Prof. E. S. Holden, and those who have helped him, deserve great credit for this valuable contribution to the history of astronomers. Prof. Holden, as he tells us, became acquainted with the Bonds in his youth, and in the preface he speaks of the unfailing kindness which he and his young friends received at their hands when at the observatory. "It has been my fortune," he says, "as an observer, to repeat some parts of his (George Bond's) work, and to obtain in this way an even more accurate judgment of his persistent thoroughness."

William Cranch Bond's father was a true Cornishman, and it is said that the family never ceased to regret their immigration to America. "A loyal love of England was characteristic of the family for many years. In household customs, manners and traditions they were thoroughly English down to very recent days."

William at an early age turned his attention to astronomy, and when only fifteen years old (1804) constructed an excellent chronometer, and also a quadrant which proved a very serviceable instrument. His taste for mechanical contrivances was considerable, and, as is now well known, he became very distinguished in this direction. Much interesting information is brought together in this volume, which shows that William Bond's career was by no means a smooth one, although it was rewarded with great success. The chronograph, now an important adjunct to meridional work, we owe to his mechanical ingenuity, and it is interesting to note that he was the first American to be elected a Foreign Associate of the Royal Astronomical Society.

William's son, George Phillips, was perhaps even more remarkable than his father in the amount of work which he accomplished. His *Magnum opus* on the great comet of Donati is perhaps the best known of his contributions, but there are others which were of nearly equal importance. It may be mentioned here that he was awarded the gold medal of the Royal Astronomical Society for the splendid memoir just referred to, but the official notification of the award reached America some days after his death. The nebula of Orion was minutely examined by him in the winters of 1857-8-9, in order to check the drawing made by his father, and investigate the truth of the remarks of Otto Struve, who criticised the positions of the stars in the engraving. This memoir is also of considerable importance, and illustrates the thoroughness which he displayed in his observational work. George Bond's forecast of the future of photography in its application to celestial physics has shown that he thoroughly understood the whole question, and, as Prof. Holden remarks, "he is the father of celestial photography."

The volume before us contains several interesting extracts from the diaries of George Bond, which include many important facts about his life. The extracts from his notes, made during two visits to Europe in 1851 and 1863, will be found very pleasant reading, as Bond visited most of the important observatories on this side of the Atlantic. His interviews with and descriptions of the astronomers of that day abound with interesting matter. In an account of his visit to Paris, he says about Leverrier:

"In the frankness of his manners, in the absence of all *assumed* dignity, and in other points of resemblance, he is not unlike Mr. Adams. His straightforward way of expressing himself, and absence of all ostentation, render him what I should call accessible."

These diaries are followed by a collection of George Bond's correspondence, while the last chapter is devoted to an account of the scientific work accomplished by both the father and son. A useful appendix is added

containing a list of the scientific writings of the two Bonds, compiled by Mrs. Richard F. Bond.

We cannot bring this notice to a conclusion without referring to the admirable way in which the lives and work of these two men have been set forth, and to the excellent reproductions of those celestial objects which will always be connected with their name, namely, Donati's Comet and the Nebula of Orion.

WILLIAM J. S. LOCKYER.

OUR BOOK SHELF.

Hints to Teachers and Students on the Choice of Geographical Books for Reference and Reading; with Classified Lists. By Hugh Robert Mill, D.Sc., F.R.S.E. Pp. 142. (London: Longmans, Green, and Co., 1897.)

A BIBLIOGRAPHY is always a difficult work to compile satisfactorily, and it becomes an even more delicate undertaking when an eclectic method is followed. The "Bibliotheca Geographica," which Herr Otto Baschin edits for the Berlin Gesellschaft für Erdkunde, is an example of the comprehensive type of bibliography, and Dr. Mill's little book admirably represents the type which aims at being serviceable rather than complete. Of the direct value of the book to teachers of geography, and indirectly to the science of geography, there can be no question: what surprises us is that Dr. Mill should have had the temerity to prepare it. Few people care to publish lists of what they consider to be the best books on any particular subject; and those who do commit themselves are often afterwards visited with mild regret. The author of this book, however, occupies an exceptional position for knowing what geographical works are in existence, and his lists of books show that he has made his selections carefully and with a mind free from prejudice. The volumes are classified under seventeen different headings, and dealt with in as many sections. A chapter on the principles of geography forms a suitable introduction to the more practical part of the work.

But a list of books, even when annotated, is not a sufficient guide to a teacher, and it needs to be supplemented by a few remarks upon the general utility and educational value of the works mentioned. We are glad, therefore, that Dr. Mill precedes each list with a brief description of the particular branch of geography, or the continent, to which the books refer, and with hints on the use of the books. From the notes and the lists it is easy to learn what volumes are best to read, and where to turn for trustworthy information upon any geographical subject met with in ordinary life. The student may refer to the book with confidence, and the teacher of geography will benefit by taking it as his guide.

We notice that the volume was prepared at the request of the Geographical Association. The Association could find no better way to further its objects than by encouraging the publication of works of this character.

Sleep: its Physiology, Pathology, Hygiene and Psychology. By Marie de Manacéïne. Pp. vii + 341. (London: Walter Scott, Ltd., 1897.)

THIS book is divided into four chapters dealing with the subdivisions of the title. A good account is given of the phenomena and theories of sleep. The chief abnormalities are well described, and the author includes an account of certain allied conditions, such as double consciousness and Latah. The references to general pathology in this section are apt to be somewhat antiquated, as when the mental enfeeblement of goitre is ascribed to withdrawal of blood from the brain. The subject of hygiene of sleep is evidently that to which the special work of the author has been devoted. She lays great stress on the proper management of sleep, and has somewhat novel views on the evils of prolonged sleep, and of fixed hours for sleep, and on the harmfulness of rocking babies in order to make them sleep. She describes very fully a condition which she terms the hypnagogic or half-awakened state, a condition characterised by increased suggestibility which is regarded as having an unfavourable influence on the mind if allowed to become well developed.

The chapter on psychology is devoted chiefly to dreams, of which a good systematic account is given, without anything especially new. The author seems to regard dreaming as an indication of high mental development; "dreams increase with the variety and activity of mental life," because intellectual workers dream more than servant girls. May this not be due to the fact that servant girls are usually the sounder sleepers?

Lessons from Life, Animal and Human. With an Introduction by Rev. Hugh Macmillan, LL.D. Pp. xvi + 529. (London: Elliot Stock, 1897).

THIS book is intended for preachers and Sunday-school teachers, and the lessons which it draws are not inferences but moral analogies. Thus an account of the bower bird establishes the maxim that "the relief times of life secure bodily and mental energy, and good spirits." The advertisements at the end of the book inform us that there are several volumes on the same plan, and that they have a good sale. The one before us is a compilation from many authors, with Darwin at one end of the scale and a crowd of obscure or anonymous writers at the other. The author is not particular in his choice of materials. He draws lessons from the most unlikely stories, and his familiarity with the literature of natural history can be estimated by the fact that he attributes to George Shaw the delightful account by Gilbert White of the behaviour of Timothy, his tortoise, in a shower of rain. The illustration or epigram from nature, which is so attractive in Shakespeare and other great writers, is here reduced to a "sad, mechanic exercise." When the allusions and emblems are arranged in cyclopædias, so that the preacher has only to look up a virtue or a vice in the index to find a more or less appropriate analogy, it is plain that the didactic anecdote is now "hackneyed and worn to the last flimsy thread."

L. C. M.

All about Animals, for Old and Young. Oblong 4to. (London: George Newnes, Ltd., 1897.)

ALTHOUGH the title is somewhat pretentious, this collection of large size photogravures is an enormous advance on the old-fashioned animal picture-books; and the volume forms an attractive Christmas gift for young people interested in natural history. All the plates are good, and some are excellent, although a few suffer from over-enlargement. A naturalist will, however, notice that one plate of deer is wrongly named; and a few emendations might here and there be suggested in the explanatory letter-press. This is for the most part well and brightly written, and serves to enhance the interest of the figures. In the first half of the book the greater number of the illustrations are from photos by Mr. Gambier Bolton, but in the second half other artists' names appear. And many of these latter are merely repetitions of the animals figured in the first half. This is decidedly a pity, as many other species might have been introduced. In a future edition these replicas might be replaced by others; and a rearrangement of the whole series in some sort of order would also be advisable. Even as it stands the book ought to, and doubtless will, command a large sale.

R. L.

LETTERS TO THE EDITOR

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. *No notice is taken of anonymous communications.]*

Transpiration into a Space Saturated with Water.

FOR some time past[1] I have been endeavouring to decide whether the energy used in raising the water of the transpiration current is derived solely and directly from the inflow of heat at the evaporating surfaces of the leaf-cells, or whether stored energy (*i.e.* vital force) is in any way responsible for work done.

It has been observed that plants transpire into a space saturated with moisture. But I am not aware that it has been pointed out that this transpiration will continue even when no light falls on the leaves. Without this precaution we cannot assume that the space is really saturated at the surface of the leaves; for they will convert some of the light into heat, and so lower the state of saturation at their surfaces.

In my experiments small leafy branches were cut and set in a watery solution of eosin under a glass receiver. Beside the vessel containing the eosin, and under the receiver, a beaker filled with boiling water was placed. The receiver became immediately filled with water vapour, and, as the space was continually falling in temperature, owing to the cooling of the beaker, it remained always in a state of saturation. These arrangements were made in a feeble light, and then the receiver branch and all were set in total darkness. It is to be mentioned that a wet board cut off the direct radiation of the beaker from the branch. After an hour it was found that the eosin had risen into the leaves of the branch. In order to ensure that this rising was not due to reduced air pressure, previously obtaining in the water conduits of the branch, experiments were made in which any reduced pressure was equalised by setting the branch for one hour standing in water under the receiver, before setting it in eosin. The same result was obtained in these cases.

The raising of the eosin in this experiment seems probably due to a pumping action in the cells of the leaf, depending upon vital processes taking place there. This surmise is confirmed by the fact that the elevation of the eosin does not take place in a saturated atmosphere if the leaves have been killed. This may be proved either by leaves killed by immersion in water at about 90° C., or by exposure to chloroform vapour.

If the pumping action be a "vital" process we would expect it to be dependent upon a supply of oxygen, like growth and grotropic curvatures, &c. We, in fact, find this to be the case. Thus a branch wholly surrounded by water will draw up eosin from a vessel below, if exposed to light. The raising of the eosin will be but little if the light be cut off from the submerged branch. The action of light supplies the leaves with oxygen set free by assimilation; in the dark, however, the leaves can only obtain the small amount of oxygen dissolved in the water, and perhaps a little, too, derived by intramolecular respiration. With this limited supply the elevation of the eosin is inconspicuous.

The oxidising processes taking place in the leaf-cells must bring about some minute rise in temperature. This will, of course, favour evaporation. But I think this effect would be far too small to account for the whole phenomenon of transpiration into saturated spaces, as I have here described it.

That a very considerable amount of the pumping action is located in the leaves, may be shown by employing large leaves set upright in the eosin. It will be found that in a dark saturated space the veins of such large leaves severed from the stem will quickly become injected with the colouring fluid.

HENRY H. DIXON.

Trinity College, Dublin, December 14.

The Zeeman Effect Photographed.

IN the number of NATURE issued on September 2, 1897, a short account is given (p. 420) of the recent work which has been done in the study of "the radiation of light in the magnetic field," and it is there remarked that it would be very desirable if the effects described by Prof. Zeeman were reproduced by photography. This, indeed, appeared to be all the more necessary in consequence of the doubts expressed and entertained as to whether the effect was a simple broadening of the spectral lines, or the production of doublets and triplets, or a combination of both effects. I accordingly availed myself of the opportunity afforded me, through the courtesy of the Royal University, of using for this purpose the splendid Rowland's concave grating mounted in the Physical Laboratory at Earlsfort Terrace, Dublin.

After the usual amount of preliminary difficulties and failures, I have finally succeeded in actually photographing all the appearances described by Prof. Zeeman, and I herewith enclose three small negatives which show the general character of the phenomena, and verify Zeeman's observations.

I do not now propose to enter into any particulars as to measurements, &c., so I shall merely describe the photographs.

The line represented is the violet line of cadmium which lies nearest to the blue, its wave-length being 4678. Plate A is taken with the slit viewing the spark *across* the lines of force of the magnetic field. The electro-magnet being excited, we have the triplet marked 1. The current was then turned off, and 2 was taken, which shows the line in its normal condition. A nicol was then inserted between the lens and the slit, and 3, 4, 5 were taken. Of these 4 shows the line when the magnet is not excited, while 3 and 5 were taken with the magnet excited. The position of the nicol in 5 was at right angles to that in 3, and as in 5 the side lines of the triplet have disappeared, it is proved that they are plane polarised. A faint middle line is shown in 3, but in my other photographs this line of the triplet is very weak, showing that it is mainly plane polarised in a plane at right angles to that of the side lines of the triplet. This is shown more distinctly in plate B, where 6 and 8 were taken with the excited field and the nicol interposed, the position of the nicol in 8 being at right angles to that in 6. The line marked 7 was taken with the magnet unexcited.

The third plate, C, was taken with the slit viewing the spark *along* the lines of force in the usual way through an axial aperture in one of the pole-pieces. In this plate the line marked 9 was taken with the magnet unexcited, whereas 10 was taken with the field excited. The latter is a distinct doublet, and a photograph which I took to-day with a quarter wave-plate and a nicol interposed, shows that the lines of the doublet are circularly polarised in opposite senses.

I wish to thank Dr. W. E. Adeney, the curator of the University laboratories, by whom the grating was mounted, for all the trouble he took to facilitate my work, and also Prof. Barrett, of the Royal College of Science, who kindly lent me his electro-magnet.

THOMAS PRESTON.

P.S.—You will observe that all the effects described above are clearly visible on the plates (which I have forwarded) by aid of any ordinary magnifying glass. They lend themselves admirably to lantern projection, and when thrown on a screen the effects may be shown to a large audience. It is to be clearly understood, however, that the description above applies to this particular line (it is also true for other particular lines); but it is not implied that the same effect precisely is produced in every other line, either of the same or of different substances.

I am making further observations on this latter point, and hope to publish my results shortly.

T. PRESTON.

November 19.

[The negatives referred to by Mr. Preston show clearly the effects described, but they do not lend themselves to satisfactory reproduction, even when enlarged.—ED. NATURE.]

The Small Tortoiseshell Butterfly in December.

I SEE in more than one daily paper of this morning's date a paragraph announcing the appearance of a small tortoiseshell butterfly in Highgate Police Court yesterday as something unusual.

This butterfly is more or less common wherever nettles grow freely, and there is a succession of broods throughout the fine season, the last of which hibernates and reappears early in spring (in mild winters in the southern counties as early as February, or perhaps occasionally even in January). It is easily disturbed in its winter quarters, so there is really nothing surprising about its appearance now. The small tortoiseshell is usually one of the latest butterflies to retire from notice in autumn, and one of the first to reappear in spring.

Chiswick, December 21.

W. F. KIRBY.

[1] *Cf.* Report of a Discussion on the Ascent of Water in Trees, *Ann. of Bot.*, December 1896.

NYASA-LAND.[1]

SIR HARRY JOHNSTON has had a unique opportunity, and he has made the most of it. Most areas in Africa over which European protectorates have been established during the past twenty years are vast in size, varied in population, as a rule unhealthy in climate, and commercially unprofitable. In the Congo Free State, Rhodesia, British East Africa, Damaraland, German East Africa and Erithrea, all the best efforts of the administration have been necessarily devoted to a struggle against almost insuperable difficulties. In these cases the leaven of European yeast is so small in proportion to the vast bulk of African meal, that one part of the mass has begun to putrefy before the rest has lightened.

It fell, however, to Sir H. H. Johnston's lot to administer a district of exceptional promise, in which a group of Scotch planters and missionaries had been settled for many years. He found a number of men willing to help, and already possessing a considerable knowledge of the country and people. The protectorate is comparatively small and compact; and yet it includes a varied series of soils and climates. Most of the district is—for tropical Africa—fairly healthy. The natives are all Bantu. The Administrator was well backed financially, and had the implicit confidence of the Foreign Office officials. Hence he had an opportunity for developing the country on experimental lines that might make it a model for the larger and more chaotic European protectorates. How far Sir H. H. Johnston has succeeded in this task is shown in the magnificent work which he has published at the end of his term of office in Nyasaland. That is, however, a political question, which need not therefore be considered here, and we may at once pass to the consideration of the section of the work of scientific interest. For Sir Harry Johnston is fortunately a man of culture and scientific tastes, which his position gave him opportunity to satisfy. Hence at the end of his term of office in Nyasaland he has been able to publish a monograph upon the country, describing its history, its climate, its people, fauna and flora. The Germans have made great progress with an elaborate monograph upon German East Africa; but that is the work of a large staff of officers, whereas Sir Harry Johnston's is a one-man book, based on the studies carried out by a busy official during the intervals of administrative worries.

The title of the work, "British Central Africa," is somewhat confusing, as the author uses the name in two different senses: on the title-page and maps it includes all the British territories between the Zambesi on the south, and German East Africa and the Congo Free State on the north. It was in this sense that the term was originally proposed, at a time when it was hoped that the Blantyre Highlands would have been the administrative centre for a vast British territory, which would have connected British East Africa with the British dominions south of the Zambesi. Sometimes in the book the name British Central Africa is used in its original sense, and sometimes only as a synonym of Nyasaland Protectorate; excluding the western five-sixths of the country, which in 1894 were transferred to the administration of the British South Africa Company. Thus on pp. 152-154 there is a summary of "the present method of administration of British Central Africa," in which only the Nyasaland Protectorate is considered. Any one who failed to recognise the double sense in which the author uses his title, might infer that no progress has been made in the administration of the vast territory to the west of Nyasaland. It would, perhaps, have been as well to have entitled the book the "Nyasaland Protectorate," for the monographic treatment, which is its main merit, is entirely limited to that area. The great western territories are often referred to; but so scanty is the treatment they receive, that the name of that hardworking administrator Major Forbes is not even mentioned.

FIG. 1.—Captain Sclater's road to Katunga in process of making.

The book opens with a series of graphic descriptions of the various types of country included in British Central Africa, using the term in its wider sense. The author vividly depicts the beauties of the jungle-bordered rivers, of the scrub-covered foot hills, of the cypress forests near the mountain summits, of the meadowland on the high plateau, of the rough, craggy, granite kopjes, and of the squall-tossed lake. Included among the word pictures of these beautiful scenes is a graphic sketch of the death-bed of a mining prospector, which would not be out of place in a religious tract.

The second chapter gives a short account of the physical geography of the country, accompanied by three admirable maps and a series of excellent illustrations. The political history follows. There is a brief summary from prehistoric times up to 1889. One interesting suggestion here advanced is that the ancestors of the existing Bantu inhabitants of Southern Africa first invaded the region south of Lake Chad about 2000 years ago—a conclusion based on the wide distribution of the native name for fowl. After 1889 the history naturally becomes more detailed, for then began Sir H. H.

[1] "British Central Africa. An Attempt to give some Account of a Portion of the Territories under British Influence North of the Zambesi." By Harry H. Johnston, K.C.B., F.Z.S., &c. 8vo. Pp. xix + 544, with 6 maps and 220 illustrations. (London: Methuen and Co., 1897.)

Johnston's connection with the settlement. Chapters follow on the slave trade and on the European settlers; future additions to the ranks of the latter are advised in an appendix that civilisation has reached a stage in the Shire Highlands which makes a dress suit more useful than a pith helmet. A special chapter is devoted to the missionaries, to whom the country owes much; the debt is fully acknowledged, but the missionaries are reproached for the cant and the inaccurate reports written to "gammon" the British public.

The last four chapters of the book deal with the natural history. The botanical section includes a valuable list of Nyasaland plants compiled by Mr. J. H. Burkill. The first collections were made by Sir John Kirk in 1861 and 1862; and judging from the frequent repetition of the names of collectors in the catalogue, the three principal subsequent contributors have been Prof. G. F. Scott-Elliot and Messrs. J. Buchanan and A. Whyte. The general chapter on the flora calls attention to the most conspicuous and interesting plants; the remark of most general interest in this section is the author's repeated protest against Dr. Russel Wallace's well-known view that the tropics have less gorgeous displays of bloom than temperate regions, an impression, Sir Harry Johnston remarks, "formed from an exclusive acquaintance with the dense forests of Tropical America and Malaya."

The zoological chapter consists of lists of the animals, most of which have been determined by the staff of the zoological department of the Natural History Museum, with general notes by Sir Harry Johnston. The lists of insects are relatively the shortest, but the author confesses to "a sweeping hatred of the insect race" "It is surprising, to my thinking," he remarks, "that our asylums are not mainly filled with entomologists driven to *dementia* by the study of this horrible class." He says he cannot call to mind "one insect that is of any benefit to man . . . with the doubtful exception of the bees and the Cochineal Aphis," ignoring, therefore, the scavenging function of the flies, the chemical and medicinal products of the galls, the silkworm, and other such invaluable servants of man. The author appears most interested in the mammals, among his notes on which some original suggestions are made. With the author's usual courage, he runs a tilt against zoological nomenclature; he objects to Burchell's zebra being regarded as the type of the species "merely because it was the first one to be discovered"; and then renames the species *Equus tigrinus*. The varieties *burchelli*, *chapmani*, and *granti* he regards as only varieties of *Equus tigrinus;* while the name *Equus crawshayi*, that of the Nyasaland zebra, is ignored altogether. Sir Harry Johnston's views on phylogeny are as much his own as his methods of nomenclature. He publishes (p. 310) a diagram showing "the origin and relationships of modern groups of Horned Ruminants." According to this novel diagram the giraffe, which is usually regarded as a descendant of *Sivatherium*, is represented as one of the offspring of the Chevrotains. The prongbuck, definitely included by the author among the antlered ruminants, is shown as a branch of the giraffe stem. All the antelopes, sheep, and goats and the musk-ox are derived from the Capricorns, a group which is again a direct descendant from the Tragulidæ or Chevrotains. Early in the work the author tells us that our views on the relations of African mammals may be at any time "upset by unlooked-for discoveries," and too late in the day illustrates this view by referring to *Nesopithecus* (*sic*), a discovery which he describes as of "the most extraordinary importance and interest," apparently unacquainted with the recent literature of the subject.

The last section of the monograph describes the people, and here the author speaks as an expert as well as an enthusiast. The section includes a most valuable series of vocabularies, and detailed descriptions of the people and their habits. Some of the descriptions, indeed, are probably too detailed; much is recorded, though half veiled in dog Latin, which might have been more appropriately relegated to the pages of a strictly anthropological journal, instead of being published in a work the rest of which is suitable for general circulation.

The author's eulogy of his colleagues, notably the present Commissioner Mr. Alfred Sharpe, and his tribute to the chivalrous courtesy with which the Portugese always behaved in their relations with him, are instances of the author's tact and fairness, and they illustrate the spirit in which the work is written. The book is in every way worthy of Sir Harry Johnston's industry and scientific attainments, and will remain the most enduring memorial of his seven years' work in the development of the most promising of our tropical African possessions. Moreover, the illustrations, two of which

FIG. 2.—A Male Reedbuck's Head.

are here reproduced by the courtesy of the publishers, are probably the best ever issued in an English book on Africa.

CHRISTMAS MUMMERS.

PROBABLY not a few readers of NATURE have, while staying over Christmas at a country house, been asked into the hall during the evening of Christmas Eve to witness a strange and fantastic rural performance called the mummers' play, and probably, too, they have promptly dismissed the whole thing as an idle and unmeaning piece of country folly. They would have noted, perhaps, the rude dialogue, the characters of St. George, the Prince of Paradine, and the King of Egypt; and they would have concluded that the performance was a faint echo of some miracle play of the Middle Ages, when the Church adopted this means of teaching the people.

Alike in the dismissal and in the uncareful noting of the characters, these observers of the country folk would have been wrong. The Christmas mumming play is worth attention, and more than mere casual attention.

Like other things which are done by the peasantry periodically, it is done by tradition, and traditional doings have a habit of getting weather-worn, so to speak. Some portions of them will remain fairly prominent, other portions will be more obscured; and so the proper sense of proportion among the different parts of the once perfect whole has disappeared. This is what has happened with the mumming play. St. George and his Eastern companions have remained in undue prominence with reference to other characters, and hence it has come about that the really archaic character of these plays has been lost sight of.

I need not describe the performance. Versions have been printed in the *Transactions* of the Folk-lore Society, and they have been examined scientifically by Mr. Fairman Ordish; but I will try briefly to explain the origin of these mimic representations of forgotten things.

The first thing to observe about the play is that the dialogue is in a state of decay. To restore it to anything like its earlier form would require the careful collation of all the versions with a view of ascertaining the portions that are practically common to all, the portions that are common to only a few variants, and the portions that are unique. This operation needs extension, too, beyond the mere mummers' play, for there are the Pace Egg play, the sword dance, and the Plough Monday play, which have most of the characteristic features of the mummers' play, and cannot but be products of the same original. After the dialogue is duly examined, there is the action of the play to consider. It is remarkable that all the actors in the different parts of the country from North England to Cornwall, however widely they differ in their dialogue and in the names of their characters, differ very little, if at all, in their action. The chief features of this action are found to be (1) the drawing of a circle with a broom for the place in which the play is to be performed; (2) the fight, in which the swords are very carefully locked together round the neck; (3) the death and revivification of the champions; (4) the costume of the characters, partly made of paper to imitate armour, as some writers have thought, but leaves of trees, as I think I shall be able to prove, and partly in imitation of animal characters.

Now in this traditional form of acting and of dressing there is more of archaic survival than in the dialogue part of the play. The circle which is formed for the players to act in is meaningless, unless it be interpreted as a magic ring drawn or constructed by the broom—that is the magic weapon of the witch, about which Prof. Karl Pearson has recently written so ably. The invariable position of the sword leads us to its parallel in the sword dance of the north of England, and hence to innumerable links with Scandinavian ritual. The death and revivification of the warriors is the reproduction of that eternal contest between winter and spring, which is to be found throughout the agricultural ceremonials of the European people, and which Mr. Frazer has examined so thoroughly. The costume of the players, some examples of which, thanks to Mr. Fairman Ordish, are to be found in the Anthropological Museum at Cambridge, connects the characters with the ritual belonging to the tree and animal cults of an almost dateless past. And in the whole thing we have, I doubt not, one of those "manifold though never developed germs of dramatic representation" of which Grimm gives some interesting examples, and which he explains "can be traced up to the most antique festivities."

Let me shortly state the arguments in support of this view. The contest, the death, and the revivification, are the central factors which need explanation, and this can best be done by examining their accompaniments, the setting, so to speak, in which they are embedded. We first of all dismiss the period of Christmas as being the special period of these mumming plays. It has grown to be so now; but that this is a late growth is shown by the fact that the same play is to be found, performed under another name, the Pace Egg, at Easter, and that significant parts of the same play are to be found performed as the Plough Monday play of early spring time. This agrees with the rule of most of the surviving traditional festivals attached to particular periods or dates of the Christian calendar. They are at some places attached to one festival, in other places attached to another, and it seems certain that these ancient ceremonies were transferred to the Christian season most favourable locally to their continuance, but not necessarily the same period of the year as they were originally performed. Without then fixing upon any of the Christian festivals as the archaic season for the play taking place, we may leave the question of date open, to be settled by other considerations. The next important point is the costume. Examining this carefully from the very modern examples which are preserved, we may conclude that the use of paper is but the adaptation of the cheapest material to be got for the purpose required. Now the paper dress is formed by stitching together a series of small pieces in a sort of scaly fashion, and the only two suggestions to account for this are first scale armour, secondly leaves. Against the idea of scale armour being present in the minds of the rustic performers there is much to be said, and particularly that scale armour is not in accordance with the other conditions of the play. In favour of leaves being intended there are many examples, notably the Jack-in-the-Green of May Day, of such dresses being used in these popular dramas; and, further, there is the fact that some of the mummers, or maskers as the name implies, formerly disguised themselves as animals—goats, oxen, deer, foxes, and horses being represented at different places where details of the mumming play have been recorded. It seems, then, that we have as data for ascertaining the principal features of the mumming play: (1) the undoubted fact of animals being represented; (2) the deduction that trees were also represented; (3) a contest, which resulted in the death of one of the opponents; (4) the restoration of the dead to life. Now mimic representations of an archaic ceremony in which actors take the parts, both of animals and trees, are found all over Europe, and they take place at spring time, just when leaves have once more appeared after the desolation of winter. This association of facts in the spring-time festivals can be equated with the association of facts in the mumming plays with sufficient precision to make it safe to conclude that the equation is due to a descent from a common original.

What is that original? In the personages who are thus slain in mimicry, to adopt Mr. Frazer's language, it is impossible not to recognise representatives of the tree spirit, or spirit of vegetation, as he is supposed to manifest himself in spring. The object of slaying the spirit of vegetation at any time, and above all in spring, when his services are most wanted, is that the divine life, incarnate in a material and mortal body, should be conveyed from the old representative of the god to a new incarnation. The killing of the god is only a necessary step to his revival or resurrection in a better form. Students of Mr. Frazer's work will not need to be reminded of the details of this argument, but I point out that they explain adequately not only the leafy and animal dresses of the English mummers, but the death and revivification of the principal actors; and they find their most archaically developed form in the Norse mythic fight between Thok and Balder, in other words between winter and spring.

What then, it may be asked, is to become of St. George and his Eastern companions, if all, except these, have so great an antiquity? The answer is that they are the later engraftings, and the answer is fortunately one

which can rather confidently be given. Folk-drama, like other branches of folk-lore, needs studying carefully and minutely to see what its chief essentials are. It is clear that the Church could not repress the dramatic representations of the people. So they utilised them. They turned characters belonging to the primitive religion into characters bearing the names of, and having just the slighest resemblance to, Christian characters. St. George was a knight who fought and slew enemies. He was fitted to do the fighting therefore in these old plays. But he did little else. He had to conform to traditional ways, if he introduced non-traditional speeches. He had to see his slain enemies restored to life, and he had to dress in the traditional manner and meet the traditional animal characters. Except, indeed, for the names of the characters there is nothing in these mumming plays really belonging to Christian knighthood and feudal nobility. No one would dream of attributing to them any of the dignity of romantic chivalry; they remain as they were originally, traditional representations of popular festivals. There is only the rudest action and the most archaic ideas; and it is not difficult, therefore, to get rid of the thin veneer of ecclesiastical influence in order to search for the more archaic relics underneath.

LAURENCE GOMME.

NOTES.

AT a meeting on December 15, Sir W. H. Flower, K.C.B., F.R.S., was elected an Associate of the Royal Academy of Sciences of Belgium.

PROF. G. CAREY FOSTER, F.R.S., will resign the Quain Professorship of Physics, University College, London, at the close of the present session.

DR. AUGUSTUS D. WALLER, F.R.S., Fullerian Professor of Physiology and Comparative Anatomy at the Royal Institution, has resigned his chair.

IT is with deep regret that we announce the death of Prof. T. Jeffery Parker, F.R.S., professor of biology in the University of Otago. Though Prof. Parker died on November 7, the news has only just reached this country; and it is given melancholy interest by the fact that the "Text-Book of Zoology," upon which Prof. Parker had for some time been engaged with Prof. Haswell, was only completed a few days before his death.

THE Council of the Chemical Society have recommended the following as Foreign Members to be balloted for at the next meeting, January 20:—Prof. Remsen, Baltimore, U.S.A.; Prof. Troost, Paris; Prof. Moissan, Paris; Prof. Raoult, Grenoble; Prof. Ostwald, Leipzig; Prof. Curtius, Bonn; Prof. Mensutkin, St. Petersburg; Prof. Markownikow, St. Petersburg; Prof. Arrhenius, Stockholm; Prof. Waage, Christiania; Prof. Franchimont, Leyden; Prof. van der Waals, Amsterdam; Prof. Spring, Liége; Prof. Körner, Milan.

WE regret to learn that Prof. Francesco Brioschi, president of the R. Accademia dei Lincei, died at Milan on December 13.

THE *Athenæum* announces that the mineralogist Dr. Albrecht Schrauf, author of several scientific works—among others of a "Lehrbuch der physikalischen Mineralogie," of a "Handbuch der Edelsteinkunde," and of an "Atlas der Krystallformen,"—has just died at Vienna in his sixtieth year. Dr. Schrauf was professor of mineralogy at the University of that place, and director of the Mineralogical Museum.

THE death is announced, at Cape Colony, of Prof. James Holm, late Professor of Physics at the South African College, Cape Town. Prof. Holm (says the *Electrician*) was born in Argyllshire in 1869, and had a brilliant career at Glasgow University, passing on to Edinburgh. Subsequently he spent several sessions in private research, under the special direction of Lord Kelvin, in the physical laboratory of the Glasgow University, and also in the electrical engineering workshops. At the completion of his scholarship he was appointed Demonstrator in Physics at the University College, Nottingham, where he remained until appointed to a professorship at the South African College in 1895.

MR. H. F. DONALDSON, Engineer-in-Chief of the London and India Docks, has been appointed Deputy Director-General of the Ordnance Factories.

THE sub-tropical Botanical Laboratory at Eustis, Florida, has been abandoned, and the work transferred to the Division of Vegetable Physiology and Pathology of the Department of Agriculture, Washington.

MR. A. C. HARMSWORTH has presented his Arctic ship *Windward* to Lieutenant Peary, and will have her overhauled and sent to America for his use in his coming Arctic expedition. This generous act is the latest incident in that series which has shown that England and America are bound by the strongest brotherly ties in their mutual interest in Arctic work.

PROF. OLIVER LODGE will commence his course of six lectures (adapted to a juvenile auditory) upon "The Principles of the Electric Telegraph," at the Royal Institution on Tuesday next, December 28. The subjects of the individual lectures are:—The production of an electric current; detection of an electric current; land telegraphy; ocean telegraphy; principles of wire and cable signalling; space telegraphy.

CHRISTMAS lectures for juveniles are increasing in favour. At University College, Liverpool, Prof. Herdman, F.R.S., will give a course of three lectures and a museum demonstration, on some of the more attractive parts of natural history, during the Christmas holidays. The announcement states that the course is for boys and girls, for whom the best places will be kept; adults will only be admitted on sufferance, should there be room for them.

THE following are among the papers announced for reading at the meetings of the Society of Arts after Christmas, in January and February:—"The Projection of Luminous Objects through Space," by Mr. Eric H. S. Bruce; "Fireproof Construction of Domestic Buildings," by Mr. Thomas Potter; "The Cinematograph," by M. Jules Fuerst.

THE will of the late Dr. George H. Horn (says *Science*) gives his valuable entomological collections, together with his entomological books and instruments and an endowment of 200 dols. per annum, to the American Entomological Society. From the residuary estate, after the death of his sister, the Entomological Society is to receive 5000 dols., the Philadelphia Academy of Natural Sciences 1000 dols., and the American Philosophical Society 500 dols.

AT the recent annual meeting of the Institution of Civil Engineers it was announced that, in respect of papers read during the Session 1896–97, the Council had made the following awards:—The Institution premium, value 10*l.*, to Mr. W. M. Mordey for his paper entitled "Dynamos"; the Paris Electrical Exhibition premium, value 5*l.*, to Mr. John Gavey for his paper on "The Telephone Trunk Line System in Great Britain"; the Fahie premium, value 5*l.*, to Mr. Benest for his paper on "Some Repairs to the South American Company's Cable off Cape Verde in 1893 and 1895." An extra premium of 5*l.* was awarded to Mr. A. P. Trotter for his paper on "The Disturbance of Submarine Cable Working by Electric Tram-

ways." The Council have decided to increase the number and values of the annual premiums commencing with the Session 1897-98 The Willans premium, the value of which the Council have increased to 25*l*., has been awarded to Mr. Mark Robinson (member) for his paper entitled "On the Recent Development of the Single-Acting High-Speed Engine for Central Station Work."

MR. G. E. BROWN writes upon a proposed memorial to Henry Fox Talbot, in the *British Journal of Photography*. All photographers are aware of the value of Fox Talbot's researches; in fact, modern photography would have no existence but for the labours of the inventor of the calotype process. Yet, as Mr. Brown points out, no mark of appreciation of his services has been made. At Bry-sur-Marne stands a monument to Daguerre; Chalons can show one to Nicephore Népce; but Lacock, in Wiltshire, the home of the Talbots, can display no sign of public gratitude. The memorial proposed is the restoration of the chancel of Lacock Church, where Fox Talbot's father and many of his ancestors, as far back as the sixteenth century, lie buried. It is probable that a more distinctly commemorative character may be given to some definite feature in the chancel, such as a window, but the whole chancel will be commemorative. Subscriptions are invited, and may be sent to the "Fox Talbot Memorial Fund," Capital and Counties Bank, Chippenham.

THE report of the Departmental Committee appointed by the Home Secretary to inquire into the testing of explosives for use in coal mines has just been issued as a Parliamentary paper. It is recommended that explosives be tested in a highly explosive mixture of coal gas and air only, and the Committee feel confident that any explosive which shows itself superior in this mixture would exhibit the same increase in safety in the presence of a coal dust mixture. Taking into account the general results of the experiments, the Committee have drawn up a test, and recommend that this should be applied to all explosives which are submitted for inclusion in the permitted list. The full details of this test are given in an appendix. The amount of the charge which it is proposed to fire will be the equivalent of 2 ozs. of dynamite and of 6 ozs. of gunpowder. In order to pass the test an explosive must not cause more than two failures in forty shots, a failure being defined as either an ignition of the gaseous mixture or an incomplete explosion. After most careful consideration it has been decided to recommend that the test be carried out with a stemming of nine inches of dry powdered clay of good quality well rammed over the charge.

THE Trustees of the British Museum have decided to discontinue the opening of the Exhibition Galleries on week-day evenings from 8 to 10 p.m. after the close of this year; and, instead, to keep them open until 6 p.m. all the year round. The evening opening commenced in February 1890, on the installation of the electric light; the galleries, however, being opened only in sections, as the electric plant is not powerful enough to light up the whole building. At first the eastern and the western portions of the Museum were opened on alternate week-day evenings; but the number of visitors so rapidly declined, that the galleries were afterwards further subdivided into three sections. The numbers, however, have still continued to decline. The experiment of evening opening, having thus had a fair and patient trial, will now be abandoned; and a lengthened exhibition by day will be substituted, during the months when the Museum has hitherto been closed at 4 p.m. or 5 p.m., according to the season of the year. On and after Monday, January 3, the Exhibition Galleries will be kept open throughout the year from 10 a.m. to 6 p.m. It is believed that the extension of time will be appreciated by visitors, particularly during the winter months, when hitherto the closing hour has been 4 p.m. The arrangements for opening on Sunday afternoons will not be altered; visitors being admitted at hours varying between 2 p.m. and 7 p.m., according to the season of the year.

THE severe gale of November 28 and 29, which caused such serious damage all along the south-east coast of this country, had the effect of raising the tide to an abnormal height, the tide of the following day being considerably depressed. Writing in the *Engineer*, Mr. W. H. Wheeler says the wind appears to have had the greatest effect in increasing the height of the tide along the part of the coast extending from the Humber to the east end of the English Channel. The wind on the previous days had been blowing strongly from the south-west, a condition favourable to increasing the height in the Channel; it then flew round to the north-west, a quarter which always raises the tide in the North Sea. The combined influence of the winds from these two opposite quarters would therefore tend to concentrate the full effect of the tide along the south-eastern coast, and the records of the damage done to the cliffs and in flooding, owing to the water breaking through or flowing over the banks, and doing other damage, show that this was the case. Fortunately the gale occurred five days after the new moon, or the effect would have been even more serious. The amounts by which the water at a few places rose above the proper tide-mark on Monday, November 29, are as follows:—Grimsby, 5 feet 11 inches; Hull, 5 feet 3 inches; The Wash (Boston Dock), 5 feet 3 inches; Lynn, 7 feet; Yarmouth, 8 feet; Ipswich, 6 feet 6 inches; Dover, 6 feet 1 inch; Gravesend, 3 feet 4 inches; Newhaven, 2 feet 4 inches; Portsmouth. 1 foot 8 inches.

THE last published *Annali* of the Italian Central Meteorological Office contains particulars of the activity of that department in various directions. One section deals specially with agricultural meteorology and the distribution of thunderstorms, and publishes a monthly review containing ten-day means for a considerable number of stations. A regular discussion of the mean weekly and annual frequency of thunderstorms and hail has been undertaken, and the results for some provinces have been laid before the Royal Academy. Another section deals specially with earthquakes, and the observations are regularly published in a monthly *Bulletin*. Dr. Agamennone, to whom we are indebted for many researches in this subject, has established a geodynamic observatory at Constantinople, with instruments similar to those in use at Rome. Considerable attention is paid to terrestrial magnetism, and the present volume contains an account of the absolute measurements of the different magnetic elements made in Italy in the years 1888-9. Among the purely meteorological discussions we may mention one on the anemometrical records at Vicenza for the fifteen years 1875-90. The author states that the diurnal velocity curve is far from showing the simplicity of a single diurnal wave.

THE properties of algebraic curves, classified on the basis of their gonality, have been studied by Prof. Amadeo, and a paper on the subject—the third of a series—is published in the *Rendiconto* of the Naples Academy (iii. 3a, 8-10). After dealing at length with the k-gonal curves of the first and second species, the author passes on to consider those of species s. The most noteworthy feature is the proof that a k-gonal curve of species s can be referred uniquely to a k-gonal curve of the first or second species, according as s is odd or even.

THE *Botanical Gazette* for November prints a very interesting history of the public gardens and plantations in Jamaica, contributed to the *Proceedings* of the Botanical Society of America by Mr. W. Fawcett, the Director. The first Botanic Garden in Jamaica was formed about 150 years ago by a private individual, Mr. Hinton East, on his property near the present village of Gordon Town, nine miles from Kingston. It was

shortly afterwards taken over by the Government, and two gardens established, a "European" and a "Tropical." But it was only within about the last thirty years that a serious attempt was made, under Sir J. B. Grant, to make the Gardens of economic value to the Colony, during which time much has been done to determine what foreign importations are most suitable to the climate. There are now six larger or smaller Gardens, viz. the Parade, King's House, Hope, Hill, Castleton, and Bath Gardens, varying greatly in their climatal conditions. Mr. Fawcett estimates that the native flora of the island includes about 450 ferns, and 2180 species of flowering plants.

ATTENTION has been previously called in our columns to Prof. Felix Plateau's observations of the way in which flowers attract insects (*Bulletin de l'Académie Royale de Belgique*), from which he inferred that the presence or absence of brightly-coloured corollas possessed little or no influence on their insect visitors. These researches are concluded in the current number of the *Bulletin* (iii. 34). Repeated experiments on seventeen species of plants, all genuinely anemophilous, prove that it is sufficient to place on the greenish or brownish inconspicuous flowers some artificial nectar, represented by honey, in order to attract numerous insects. Moreover, it appears (both from the author's personal observations and from previous writings) that insect visits, often frequent, have been observed on ninety-one forms of entomophilous plants having flowers devoid of conspicuous colour, viz. forty-one with green, thirty-eight with greenish, and twelve with brown or brownish flowers. The author has verified the coloration for seventy-two of these plants, and has himself observed the visits of insects to sixty-three, or more than two-thirds of them. Prof. Plateau concludes that insects are little affected by the presence or absence of brilliantly coloured floral organs; what they seek is the pollen or nectar, and in finding these their sense of vision is merely accessory; while, on the other hand, they are guided with certainty by some other sense, which can only be that of smell.

AN important series of investigations has recently been published in the *Annales de l'Institut Pasteur*, by Dr. Paul Remlinger, on the artificial communication of typhoid fever by the alimentary tract. Hitherto it has been customary to infect animals with the typhoid bacillus by introducing this organism into the peritoneum, but in consequence of the attention which has lately been directed to the danger of typhoid being disseminated through the direct watering of vegetables with sewage, Dr. Remlinger experimented on the possibility of infecting rabbits and rats with typhoid by feeding them on vegetables soaked with typhoid bacilli. These experiments showed that it was possible to induce typhoid fever in rats and rabbits by this means, and Chantemesse has not only confirmed Remlinger's results, but states that he has succeeded in infecting monkeys with typhoid in a similar manner. The following experiment gives some idea of the results obtained by Remlinger in this interesting inquiry. A rabbit commenced to eat typhoid-soaked vegetables on August 30; two days later its temperature rose and later on it became thin and apathetic, and on September 7 the supply of typhoid bacilli was stopped; on September 15 symptoms of diarrhœa made their appearance, and blood taken from the animal gave a positive reaction with the sero-typhoid test; a few days later the temperature became normal, and the animal gradually recovered, but on September 30 its blood still gave a positive reaction with the above test. Experimental typhoid induced in this manner in rats resembled very closely the symptoms observed in the case of rabbits. It is, however, necessary in order successfully to infect animals with typhoid by this means, to make them frequently swallow large quantities of the bacilli.

THE number of *Isis* (Dresden) for the first half of 1897 contains a paper, by Dr. P. Menzel, on the "Tertiary Flora of the 'Jesuitengraben' at Kundratitz," a very rich layer, from which a number of new species are described. A plate accompanies the paper.

THE Report of the Director of the Botanical Survey of India for 1896–97 includes reports from all the Directors of Departments except that of Southern India. The results will shortly be dealt with of the botanical exploration, by Lieut. Pottinger, of a portion of the valley of the Irrawaddy, a country hitherto absolutely unknown. A synopsis is given of the flora of Western India as far as the Tiliaceæ.

THE Tuesday evening science lectures at the Royal Victoria Hall, Waterloo Road, during January, will be as follows:—January 4, "Coal," by Mr. W. F. Rudler; January 11, "Diamonds," by Prof. H. A. Miers, F.R.S.; January 18, "Through the New Gold Fields of Alaska to Bering Strait," by Mr. H. de Windt; January 25, "Mars as a World," by Mr. R. A. Gregory.

PHILIP'S revolving planisphere is well known to be a very handy and serviceable means for finding the constellations visible at any time. A more substantial form of the contrivance, with an adjustable calendar combined, has just been published by Messrs. George Philip and Son. The arrangement is made so that it will stand alone, or it may be hung from a wall. It is thus a suitable ornament for the astronomer's desk, or for the observatory.

THE additions to the Zoological Society's Gardens during the past week include a Mandrill (*Cynocephalus mormon*, ♂), a Mona Monkey (*Cercopithecus mona*, ♂), two Green Monkeys (*Cercopithecus callitrichus*, ♂ ♂), a —— Hawk Eagle (*Spizaetus* ——), seven African Walking Fish (*Periopthalmus koelreuteri*) from West Africa, presented by Dr. H. O. Forbes; a Sykess Monkey (*Cercopithecus albigularis*, ♂) from West Africa, pressented by Mr. Henry Curnow; a Binturong (*Arctictis binturong*) from Malacca, presented by Mr. W. W. Skeat; a Blotched Genet (*Genetta tigrina*) from South Africa, presented by Mr. J. E. Matcham; a Ruddy Ichneumon (*Herpestes smithi*) from India, presented by Colonel F. Morison; two Grey Struthideas (*Struthidia cinerea*) from Australia, presented by Mr. R. Phillipps; a Crimson-eared Waxbill (*Estrelda phœnicotis*) from West Africa, presented by Miss Aves; a Thar (*Capra jemlaica*, ♂) from the Himalayas, six White Pelicans (*Pelecanus onocrotalus*) from Egypt, deposited; three Coscoroba Swans (*Coscoroba candida*) from Antarctic America, a Macqueen's Bustard (*Houbra macqueeni*) from Western Asia, purchased.

OUR ASTRONOMICAL COLUMN.

NEW DOUBLE STARS.—The discovery of new double stars at the Royal Observatory, Cape of Good Hope, by Mr. R. T. A. Innes, is proceeding apace, and Dr. Gill publishes in *Astr. Nach.*, 3462, a fourth list of such objects. The number of stars given is twenty-nine, making the total now discovered 259. The distances of the components range in this last list from 0″·5 to 5″.

NEW VARIABLE STARS.—More than once in this column it has been shown that useful astronomical work can be done with instruments of only moderate size, backed up by steady observation; but no one has done more to emphasise this fact than Dr. Anderson, of Edinburgh, first with his discovery of Nova Aurigæ, and later by a close scrutiny of stars to detect any variability. From observations made with his 2¼-inch refractor, he points out in *Astr. Nach.*, 3461, that a star in Aquila, not mentioned in the Bonn *Durchmusterung*, but whose position (possibly wrong to the extent of 1′) is R.A. 19h. 31m. 10s. Decl. + 11° 23′, has proved to be variable

Again, in *Astr. Nach.*, 3463, he gives notice of two new variables—probably of short period—B.D. + 67°·1124 in Draco, and B.D. + 30°·1329 in Gemini, with respective positions: R.A. 19h. 9m. 54s., Decl. + 67° 2′·4, and R.A. 6h. 37m. 50s., Decl. + 30° 25′.

All the positions are given for the epoch 1855.

VARIATIONS IN THE SPECTRUM OF NEBULA IN ORION.—Often has severe criticism put scientific facts on a firmer basis, and such might be said to be the case with Dr. Scheiner's doubts concerning Prof. Campbell's observed variations in the spectrum of different regions in the Orion nebula, made in 1893. To test the accuracy of some specific observations, Prof. Campbell has called in the assistance of three of his colleagues (Prof. Schaeberle amongst them), and, with the aid of the 36-inch refractor and an efficient spectroscope, different regions of the nebula have been examined to observe the behaviour of the three principal nebular lines.

The mode of making the observations was to use a coarse micrometer wire, occulting each of the lines in turn, so as to determine the relative brightness of the remaining two, when all three are observable.

The following are the results, which in the main all the observers are agreed upon:—Central part of nebula (Trapezium region): the three nebular lines all conspicuous, the line λ 5007 being the brightest, whilst the lines λ 4959 and λ 4861 are nearly of the same intensity as each other.

In the region surrounding the star Bond, No. 734, the line λ 4861 was the only one visible, the other two lines having disappeared; whilst in the region south-west of the Trapezium all three are visible, but the line λ 4861 is still the brightest.

No doubt photographs will be secured whilst Orion is well situated, and so further establish these observations made visually.

WINNECKE'S PERIODIC COMET.—One is reminded on reading the life-work of the late Dr. Winnecke, in the last number of NATURE, that had he lived a few weeks longer he would probably have seen another return of the periodic comet which bears his name, for it is due at perihelion on March 20, 1898, but of course will be better situated for observation some time before this. The elements and ephemeris as given by Mr. C. Hillebrand in *Astr. Nach.*, 3447, are as follows:—

Elements.

	26 October. 1897.	15 March, 1898.	
M =	325° 24′ 26″·7	359° 3′ 52″·0	
π =	274 14 33·3	274 14 39·0	1900
Ω =	100 53 34·3	100 53 11·5	1900
i =	16 59 34·4	16 59 33·8	1900
φ =	45 37 35·6	45 37 14·7	
μ =	608″·3483	608″·5559	

Ephemeris.

1897-98.	R.A. h. m. s.	Decl. ° ′	log *r*.	log Δ.	$i : r^2\Delta^2$.
Dec. 21	14 38 14	− 1 6·6	0·19028	0·28225	0·113
25	51 6	2 2·3	17921	26885	127
29	15 4 28	2 58·6	16788	25550	142
Jan. 2	18 24	3 55·3	15629	24228	160
6	32 53	4 52·3	14446	22929	179
10	15 47 58	5 49·3	13242	21659	200
14	16 3 40	6 46·1	12016	20432	224
18	20 0	7 42·1	10773	19259	251
22	36 59	8 37·0	09518	18151	280
26	16 54 36	9 30·3	08256	17122	311
30	17 12 49	10 21·3	06993	16184	344
Feb. 3	17 31 41	− 11 9·0	0·05738	0·15349	0·379

The best time for making a search will be early in the morning, shortly before sunrise, from about now till early in February. The comet is never visible to the naked eye, and will at first be faint with the aid of a telescope; its apparent path is in a south-easterly direction through Virgo, Libra, Scorpio, Sagittarius, and Capricorn.

KEKULÉ MEMORIAL LECTURE.

AT an extra meeting of the Chemical Society, held on Wednesday, December 15, Prof. F. R. Japp, F.R.S., delivered a memorial lecture in honour of the eminent German chemist, Friedrich August Kekulé, whose death occurred in July 1896. The lecturer said that Kekulé's supreme merit lay in his contributions to theoretical chemistry. His greatest achievements in this department were the doctrine of the linking of atoms in terms of their valency, and, growing out of this, the theory of the structure of organic molecules, both in open-chain and in closed-chain compounds. These were not recondite theories, hidden away in the depths of the science; they were organic chemistry itself, and were learnt by students on their first introduction to the subject. Kekulé acknowledged that his theories were based on Gerhardt's type theory, on Williamson's theory of polyvalent compound radicles and multiple types, and on Odling's theory of mixed types, which was a deduction from Williamson's theory. Less consciously, perhaps, his opinions were influenced by E. Frankland's theory of the valency of elementary atoms, and by Kolbe's speculations on the constitution of organic compounds. Kekulé developed these ideas, which he found scattered throughout the writings of his predecessors, added to them, and welded the whole into the coherent system which formed our present theory of the structure of organic compounds. In Kekulé's model of the carbon atom "the four units of affinity," to quote his own words, "radiate from the sphere representing the atom so that they end in the faces of a tetrahedron." This model was destined to play an important part in the development of theoretical chemistry; it was the foundation of stereochemistry. Kekulé's benzene theory was the crowning achievement, in his hands, of the doctrine of the linking of atoms; it was the most brilliant piece of scientific prediction to be found in the entire range of organic chemistry. What Kekulé wrote in 1865 had since been verified in every essential particular. Not only had the various substitution derivatives been discovered in the number and with the properties required by the theory, but various observations which appeared to contradict this theory had been proved erroneous. Moreover, the theory had shown itself to be capable of boundless development, and there seemed to be no limit to the fruitfulness of Kekulé's conception of closed chains or cycloids. The extensions of the idea, of which extensions Erlenmeyer's naphthalene formula and Dewar's formulæ for pyridine and quinoline were among the earliest instances, had gone on increasing in a rapid geometrical ratio, until, at the present day, the literature dealing with cycloids, although of so recent growth, was more than twice as voluminous as that of the paraffinoids. But even in the undeveloped state of the subject prior to Kekulé's theory, the facts were apparently so intricate and so unconnected that few chemists could claim to have mastered them. The theory appeared; the previously unmarshalled facts fell into their proper places; and not only this, but it was possible to say whether, in any given section of the subject, the facts were complete or only fragmentary. The debt which both chemical science and chemical industry owed to Kekulé's benzene theory was incalculable. As regards the former, three-fourths of modern organic chemistry was, directly or indirectly, the product of this theory; and as to the latter, the industries of the coal-tar colours and the artificial therapeutic agents, in their present form and extension, would be inconceivable without the inspiration and guidance of Kekulé's fertile idea. By the accuracy of his predictions he had done more to inspire a belief in the utility of legitimate hypotheses in chemistry, and had therefore done more for the deductive side of the science than almost any other investigator. His work stood pre-eminent as an example of the power of ideas.

RECENT RESEARCHES ON TERRESTRIAL MAGNETISM.[1]

II.

UP to this point we have regarded the system of magnetic forces in play upon the surface of the earth as constant. I have already hinted that this is not the case, and that the difficulties of our investigation are immensely increased by the fact that all the phenomena with which we deal are in a state of flux. Nothing is fixed from year to year, from day to day, from hour to hour. It is hardly too much to say that at times almost every minute brings with it changes which it is the business of the magnetician to investigate and explain. For the moment, however, I wish to fix attention only upon the secular change to which I have already referred. Not only does the angle which the magnet makes with the geographical meridian vary, but the dip also increases and diminishes in turn.

[1] The "Rede Lecture" delivered in the Senate House, Cambridge, on June 9, by Prof. A. W. Rücker, F.R.S. (Continued from p. 163.)

An interesting method of depicting these changes has lately been suggested by Dr. Bauer. He imagines the observer to be stationed at the central point of a magnet suspended so that it can turn freely in any direction. To a person thus situated, and capable of continuing his observations through periods far exceeding the range of human life, the north pole of the magnet would appear to describe a curve. It would move sometimes to the right, sometimes to the left, and would simultaneously rise or fall. The facts which have been observed during the last 150 years, and, in some places, for longer periods enable us to draw these curves. At the great majority of the places first

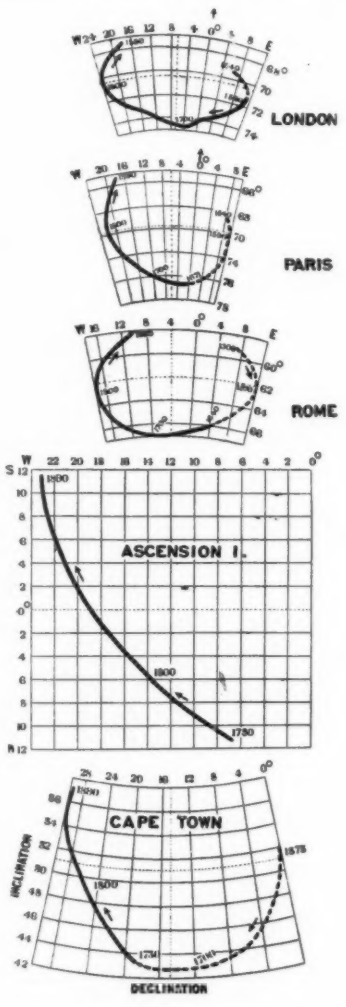

FIG. 3.

investigated the pole of the magnet would always appear to the observer to describe its orbit in the same direction as the hands of a watch, so that on the whole when the needle was to the east of its mean position it would generally be falling, and when to the west rising. Unfortunately, however, this statement is not of universal application, as there are a certain number of stations on the west coast of America where the ordinary movement appears to be reversed. If figures representing a number of these magnetic orbits are arranged, in order from north to south, as in Fig. 3, and if those selected are appropriate to places the longitude of which is not very far distant from that of Greenwich, it is found that in passing from north to south the area enclosed by the figure becomes larger, and that it again diminishes when the equator is passed. In other words, for these stations the rule holds good that the orbital sweep of the needle is greatest near to the equator. There is another curious peculiarity, namely that for stations of approximately the same latitude in the northern and southern hemispheres, respectively, the curves are larger in the Southern Hemisphere.

If, however, we turn to the American continent, the curves are different, the range of declination is less, and the figures, instead of being of an approximately circular form, become elliptical.

In no case have the phenomena been registered for a sufficiently long time to enable us to complete any one figure. For London we have fairly accurate data for about three centuries, and the earlier observations enable us to extend the curve still further backwards with some probability of accuracy. In the case of our own country we have probably followed the movement of the needle from an extreme easterly position attained in the time of Elizabeth to an extreme westerly position which was reached about 1824, but we have no right to assume that the return journey from west to east will occupy the same time as that which has been watched from east to west.

The first conclusion, then, which I wish to draw from these figures is that they and others like them display what is practically the whole of our knowledge as to the time during which magnetic phenomena go through a complete cycle of change. Calculations have been given by high authorities, which lead to the conclusion that the magnetic pole would perform an orbit round the pole of the globe in about 960 years; but a glance at the curves is sufficient to show how uncertain are the data upon which such estimates are based.

The speed with which the secular orbit is described does not appear to be constant. It may be more or less rapid in the future than in the past. The curves, though so far smooth and continuous, may in the future develop loops or irregularities of various kinds. We may doubt whether all the orbits are described in the same time. It is quite possible that the paths may not return into themselves, or be repeated in successive cycles.

These difficulties may be illustrated by another suggestive device of Dr. Bauer's. Let us suppose for a moment that the principal part of the magnetic system of the earth consists of forces due to currents or magnetic matter which are unchangeable and are arranged symmetrically with respect to the geographical axis. Let there be superimposed upon this another magnetic system describing within the earth and around the geographical axis an orderly orbit completed in an unknown term of years. Let us further suppose that this second system is itself unalterable except in position, so that, as it revolves, the magnitude of the forces is unchanged though the position of the points from which they emanate varies. Under these circumstances we should be able to foretell from the present state of the earth what the future cycle of change would be. If the magnetic needle were placed at some fixed point on the surface of the earth, it might take hundreds of years for the revolving magnetic system to make one complete revolution so as to take up every possible position with regard to the needle. But if the needle were suspended like Mahomet's coffin near to the surface of the earth, and were held there while the globe rotated beneath it, then in a single day the relative positions of the revolving magnetic system and the suspended needle would undergo every possible change, and the pole of the needle would describe in twenty-four hours the path which may in reality be accomplished in a millenium.

Of course we cannot thus suspend a magnet in space, but the same end would be attained by carrying it round the globe along a parallel of latitude, and we have sufficient knowledge of the magnetic conditions of the surface of the earth to determine the curve which the pole of the needle would describe during such a journey.

Three of these curves have been drawn by Dr. Bauer for the equator and for latitudes 40° N. and 40° S., and a glance at the diagram on which they are depicted shows that though they are larger, they bear a general resemblance to the secular curves which portray the movements of the needle at various stations near to the prime meridian. In particular the curious difference in the size of the orbits for equal latitudes north and south of the equator respectively is reproduced. Dr. Bauer has drawn curves for three different dates, of which only those correspond-

ing to two are here reproduced (Fig 4), and of course, if the basis of our argument were unimpeachable, they should be identical. This is not so; there are noticeable, although not very great, differences, but, together with other facts already mentioned, the variations are sufficient to enable us to affirm that the secular change cannot be deduced in this simple fashion from the present magnetic state of the earth.

There is one other point with regard to the curves which shows how great must be our caution in arguing from such data. In the lower parts there is a general similarity with the curves deduced from past observations with the magnet at different places near the prime meridian, but in the upper portions, which refer to the future, the curves are more complicated, and they are varied by irregularities and loops of which we have, as yet, had no actual experience. Dr. Bauer has observed most praiseworthy caution in deducing any definite conclusions from these interesting speculations. But even if we refuse to accept his hypothesis that there is a more than accidental connection between the secular curve which the pole of the magnet describes at any one place, and the curve which it would describe if carried round the earth in the latitude of that place, there can be no question that it is possible that irregularities similar to those seen in the one set of curves may in the future occur in the others, and that any deduction which we may make as to the for any hint as to a possible physical explanation of the secular change.

In addition to the long-protracted changes which have been discussed, the pole of a freely-suspended magnet also describes an orbit from day to day, which is so small, when compared with the secular path, that hitherto I have neglected it. This diurnal change has long been studied. Its magnitude varies from time to time and has been found to be connected with the season of the year and with the sunspot period. On these comparatively well-known facts I will not dwell, but there is one point in connection with the diurnal variation which has recently been attracting attention. For days together the orbits described may be very similar, but this regular motion is frequently disturbed by violent perturbations, and the pole of the magnet moves within a few minutes both to the west and to the east to an extent far exceeding that due to the ordinary diurnal motion, so that the form of the path is widely irregular. Such a phenomenon is called a magnetic storm, and from the fact that such storms occur simultaneously at places which are widely distant it has been thought that it is possible that they are due to some impulse which reaches the earth from the sun. They are also closely connected with displays of the Aurora Borealis. These irregularities make it difficult to determine what is the true normal behaviour of a freely suspended magnet. The

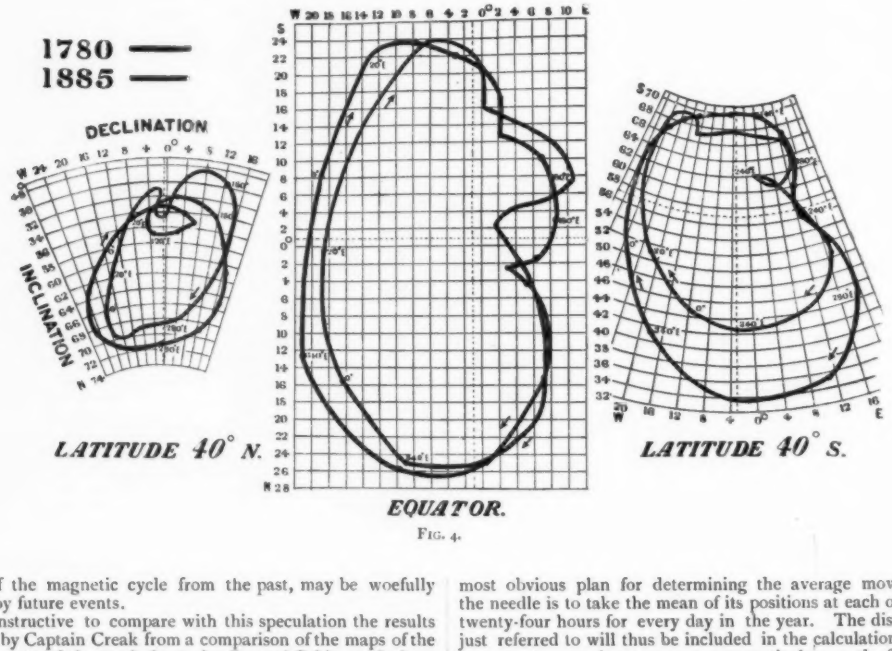

FIG. 4.

period of the magnetic cycle from the past, may be woefully falsified by future events.

It is instructive to compare with this speculation the results obtained by Captain Creak from a comparison of the maps of the magnetic state of the earth drawn by General Sabine and those which Creak himself elaborated with the aid of the observations made by the *Challenger* expedition. The conclusion to which he came was that during the forty years which elapsed between the epochs for which the maps were drawn, the secular change might be best represented by supposing that the magnetic poles were stationary, but that at certain points on the surface of the earth the forces of terrestrial magnetism had been increasing or diminishing. I have before now referred to these interesting observations in public, and I will not dwell on them again, except to remark it is possible that we may have to deal with causes both of the one type and of the other, that within the earth there may be a rotating magnetic system, and that purely local causes may also alter the intensity of the magnetic forces at different places.

Dr. Schuster has recently shown that a motion of the magnetic pole might be produced if the space round the earth were conducting. The conditions under which this would occur cannot be discussed now, but the magnetician has reason to be grateful most obvious plan for determining the average movement of the needle is to take the mean of its positions at each one of the twenty-four hours for every day in the year. The disturbances just referred to will thus be included in the calculations, but as very great magnetic storms are comparatively rare, the final value will not be very largely affected. This process is very laborious, and exceeds the powers of any except the best equipped observatories. Some time ago, therefore, it was suggested that the calculations should be shortened by the selection of quiet days only, on which it was to be supposed that the behaviour of the needle was normal. Five days in each month were considered sufficient, and by a happy arrangement all the English observatories have agreed that these days shall be chosen by the Astronomer Royal, and that thus the determination of the normal movement of the needle shall be made by all of them from data collected at the same time.

Attention has recently been drawn to the fact that, whatever the convenience of this five-day method may be, it leads to the conclusion that at the end of a quiet day, the needle does not return to the position which it occupied at the beginning. This point has been carefully investigated by Dr. Chree, and may be illustrated by means of the curve which I have drawn from the Kew Observatory Report for the summer of 1895, the scale of

which is many times larger than that of the secular orbits already depicted (Fig. 5). The upward and downward movement of the needle is much smaller than the displacement east and west, so that an elongated figure is produced, but the interesting point is that it is not a closed curve; the two ends do not meet, but are separated by a very appreciable interval. It would, of course, be an easy explanation of this fact, if we could attribute it to the secular change. Just as the moon, though at the end of a month in the same position with respect to the earth as it was at the beginning, is much further advanced in the earth's orbit, so the diurnal magnetic variation must accommodate itself to the larger secular movement of which it is a subordinate part. But this explanation alone will not suffice. It is true that during the quiet days the movement of the needle in its secular path continues, but there is a good deal of evidence to show that it is of more than average speed. This is especially true of the horizontal force, which is gradually increasing and increases with remarkable rapidity on quiet days. Hence the secular movement appears to be checked by the storms. The comparatively rapid progress which has been made in quieter times, being retarded and even reversed during the periods of irregular motion which I have described.

It is true that General Sabine many years ago showed that magnetic storms do not act equally in both directions upon the needle, and that thus the phenomena which I am now describing can hardly be said to be recently discovered; but the method of presenting it which has been adopted by Dr. Chree, and which I have slightly modified by including in the diagram the variations both of declination and of dip, certainly places the facts before us in a novel and a striking light. Of what the cause of the sudden check which the needle receives during the magnetic storms may be, we can as yet say nothing. It is one of the puzzles which has yet to be unravelled.

The last point to which I will refer is one upon which more definite results have been obtained. Terrestrial magnetism is

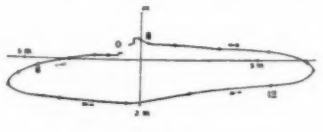

FIG. 5.

connected with phenomena which occur in the sun, with the Aurora Borealis in the upper atmosphere, and with the earth currents which traverse the soil. I have now to draw your attention to its relation to geology.

It has long been known that just as the great secular variation of the magnet is accompanied by minor diurnal changes, so the large alterations in the direction of the compass and dipping needle, which are observed when we move from place to place on the surface of the earth, are affected by irregularities which are apparently due to purely local causes. Thus the declination is greater in Ireland than in England; but the increase is not uniform as we pass from one country to the other. In fact in some districts an abnormally large increase is followed by a decrease.

These curious inequalities must be due to local disturbing forces, and the large number of observations which have been made in this country have enabled us to determine with more than usual accuracy the magnitude and direction which the magnetic forces would assume if they were undisturbed by any local cause, and from the difference between things as they then would be and things as they actually are, we can calculate the magnitude and direction of the disturbing forces themselves. When these are represented on a map, it is found that there are large districts of the country in which the disturbing horizontal forces act in the same direction; in one region the north pole of the needle will be deflected to the east, in another to the west, and, as we pass from one of these districts to the other, we always find that at the boundary the downward vertical force on the north pole of the needle reaches a maximum value. We are thus able to draw upon the map lines towards which the north pole of the needle is attracted. It is found that the exact position of these can be determined with considerable accuracy, and that the lines can be traced without any possible doubt through distances amounting, in some instances, to a couple of hundred miles. The key to this curious fact is probably furnished by observations in the neighbourhood of great masses of basalt or other magnetic rocks. If these were magnetised by the induction of the earth's magnetic field, the upper portions of them would in this hemisphere attract the north pole of the needle; and it is found that where large masses of basalt exist, as in Antrim, in the Scotch coal-fields, in North Wales, and elsewhere, the north pole of the needle is, as a matter of fact, attracted towards them from distances which may amount to fifty miles. The thickness of the sheets of basalt is in most cases too small to furnish a complete explanation of the observed facts, but it is quite possible that these surface layers of magnetic matter are merely indications of underground protuberances of similar rocks from which the surface sheets have been extruded. At all events, there is no possible doubt of the fact that where large masses of basalt occur, the north pole of the needle tends to move towards them.

There are other regions where the attractions are manifest, but where, nevertheless, no magnetic rocks occur upon the surface; but it is most probable that the cause is the same, and that it is due to the mere accident of denudation that in one case we can, and in the other we cannot, point to the magnetic rocks to which the anomalous behaviour of the compass is due. If this be so, it is certainly interesting that magnetic observations should enable us to penetrate to depths which the geologist cannot otherwise reach, and that the lines which we draw upon the surface of the map, as those to which the north pole is attracted, may, in fact, roughly represent the ridge-lines of concealed masses of magnetic rocks, which are the foundations upon which the deposits studied by the geologist have been laid.

There is some ground for thinking that if these great underground wrinkles exist, they have affected the rocks which are superposed upon them, especially those which are of a comparatively early date. As a general rule, if older rocks appear in the midst of newer ones, the pole of the magnet will be attracted towards the protruding mass; but this rule holds good only of the rocks of carboniferous or pre-carboniferous age, and does not apply to later deposits. As a striking example, I may remind you that the Pennine Range—which is sometimes called the "Backbone of England"—is a mass of millstone grit rising amid younger rocks. Down this a well-marked magnetic ridge-line runs. Similarly, in the neighbourhood of Birmingham, the Dudley and Nuneaton coal-fields are surrounded by more modern deposits. A curious horse-shoe shaped ridge line connects these two, and then runs south to Reading, which is, magnetically speaking, one of the most important towns in the kingdom. East and west from Dover to Milford Haven, and then across the Irish Channel to Wexford, runs a ridge of the older rocks called by geologists the Palæozoic Ridge, concealed in many places by newer deposits. Hollowed out in this are the South Wales and Forest of Dean coal-fields, and in another hollow within it lies the coal which has recently been discovered at Dover. Closely following this protruding mass of the older rocks is a magnetic ridge-line which passes through Reading, and we thus have a magnetic connection between the anticlinals of Warwickshire and the Palæozoic Ridge. From the neighbourhood of Reading also another magnetic ridge-line runs southwards, entering the channel near Chichester. M. Moureaux, who with most untiring energy has for many years been investigating single-handed the magnetic constitution of France, has discovered the continuation of this line on the French coast near Dieppe, and has traced it through the north of France to some fifty miles south of Paris. The energy which is now being displayed by magnetic surveyors in many countries will, no doubt before long, prove that the network of these magnetic ridge-lines is universal; and the relations between them and the geological conformation of the countries in which they lie will be so studied that our inductions will be based upon an adequate knowledge of facts.

This, at all events, we may hope, that amid the flux and change of magnetic forces with which we have so largely been occupied, we may have found in these ridge-lines physical features of the country as permanent as the hills themselves.

And now that I draw near to the end of my lecture, I cannot but feel that it has to a certain extent been wanting in organic unity. It is sometimes possible to unfold the story of a scientific advance in strictly dramatic form. The question posed, the oracle consulted, and the answer given, might well form the titles of the three acts in the modern miracle-play of scientific discovery. But the drama has its conventions, and even those authors who boast of their realism, too often falsify by over-

emphasising the points on which they chiefly dwell. If we would know life we must learn it not from the stage-box or dress circle, but by mingling with mankind. If we would know what scientific work is, we must not be content with listening only to skilfully-told tales of scientific triumphs, but must penetrate into the observatory or laboratory, where the fear of failure, and the uncertainty of long watching and waiting, are at least as frequent visitors as the assured forecast of success.

To-day, therefore, I have dealt with problems which are still surrounded by doubt and difficulty, with questions which can only be answered by the combined work of many men, it may be of many generations. It is true that on some of these matters we are gradually acquiring definite knowledge. That earth-air currents, if they exist at all, are very minute in north-western Europe; that the diurnal variation on quiet days is not necessarily to be regarded as normal; that local magnetic disturbances are due to forces so wide in their range that it is worth while to study them; these are all facts about which we were in doubt a few years ago, and on which we are in doubt no longer. But greater questions which lie behind these are still unanswered, and if I have ventured to deal with difficulties as well as with certainties, it has been because I have wished to give you a correct idea of current scientific thought on the subject of terrestrial magnetism.

MR. MERRIFIELD'S EXPERIMENTS ON THE RELATION OF TEMPERATURE TO VARIATION.

FOR the last ten or eleven years Mr. Frederic Merrifield, of Brighton, has been conducting a most elaborate and extensive series of experiments in the rearing of lepidopterous insects under various conditions of temperature. The results obtained by him are of high interest, both in themselves and also in reference to similar experiments independently undertaken by Dorfmeister, Weismann, Standfuss and others, some of which have already been noticed in the pages of NATURE. It is proposed to give here a short general account of the chief of Mr. Merrifield's experiments, with figures of some of the main results obtained. For full details the reader is referred to the original accounts which have appeared from time to time in the *Transactions* of the Entomological Society of London.

Experiments in 1887.—The first experiments undertaken had the object of supplying data for an inquiry by Mr. Francis Galton on the subject of heredity. It was anticipated by Mr. Galton that "the experiments would elicit incidentally many interesting results, some perhaps quite disconnected with the objects immediately in view." This anticipation was fully borne out by the facts.

The first species taken for experiment were two geometer moths, *Selenia bilunaria*, Esp. (*illunaria*, Hb.), and *S. tetralunaria*, Hufn. (*illustraria*, Hb.), both normally double-brooded in this country. Larvæ of both species were reared from eggs laid by females of the spring emergence; some of the moths resulting from these were selected for pairing according to size, three classes being formed, of maximum, medium and minimum expanse of wing, and the rearing of fresh generations was continued. Some of both species were fed up in the open air; these showed nothing remarkable. Others (of *S. bilunaria*) were kept during all their stages at a temperature of about 80° F., which had the effect of considerably accelerating their development. Five generations of *S. bilunaria* (counting the moths of the spring emergence as the first generation) were thus produced in the course of the year. These bred moths were all of the summer or *juliaria* form, and the females were always larger than the males, which is in accordance with the rule for the natural summer brood. The pairs selected for maximum and minimum expanse of wing produced no fertile eggs after the third generation. The fourth generation consisted entirely of the offspring of one of the medium-sized pairs of the third, and from these a selection was again made as before. The resulting moths of the fifth generation emerged in December and January, showing signs of deterioration. Only one of this brood laid fertile eggs, and these failed to hatch. The average size of the moths increased continuously up to the fourth, but diminished in the fifth generation.

Experiments in 1888.—The summer of 1888 was cold and wet, and the moths of both the selected species reared from larvæ kept in the open air showed signs of degeneration. That this was not due to the domestication of their progenitors appeared from the fact that a wild strain of *S. tetralunaria* behaved in the same manner.

It was observed in the case of *S. bilunaria* that the specimens produced from larvæ and pupæ that had been kept at about 80° F. showed a warmer colouring and fewer spots than those reared throughout their stages at ordinary temperatures. The same was found to be true in a still more marked degree of another species of geometer moth, *Ennomos autumnaria*, Wernb., and also, though to a less extent, of *S. tetralunaria*.

Experiments on the pupæ of *S. tetralunaria* led to interesting results. It was found that moths derived from pupæ of the summer brood, first retarded in development by freezing, though ultimately forced for a few days, tended, especially in the females, to assume the appearance of the comparatively dark spring emergence. Some larvæ of the same summer brood and their resulting pupæ were forced from the beginning, with the result that the same batch split into two divisions, the first of these feeding up rapidly and emerging, during the same season, with the summer colouring; the second taking much longer, and attempting to lie over for the winter as pupæ. A continuance of the forcing process brought out some of the latter in November and December, with the summer colouring. Others were exposed out of doors from November 7 to January 1, when they were brought into the house and again forced. The moths from this latter group came out in January and February, and were all of the spring colouring. Inasmuch as the continuously forced batch gave the summer form as late as December, it would appear that retardation alone is not in all cases sufficient to determine the assumption of the spring coloration. On the other hand, some pupæ of *S. tetralunaria* reared by Mr. Jenner, which were similarly trying to lie over for the winter, produced under forcing a series of intermediate forms becoming on the whole more and more like the spring type with the length of time that elapsed before their emergence. Here there was no exposure to winter cold; but only retardation from constitutional causes.

Mr. Merrifield remarks that the case of *S. tetralunaria* shows that the alternate succession of the two forms is not a necessary accompaniment of seasonal dimorphism. The same appears from Weismann's earlier experiments, in which, under appropriate conditions of temperature, the summer form *Vanessa prorsa*, L., was found to give rise in the next generation to *V. prorsa* instead of to *V. levana*, L. (the spring form).

The different reaction of members of the same brood of *S. tetralunaria* to the same conditions of temperature is interesting as an example of what may perhaps be called "physiological dimorphism"—a principle which there is reason to think is widely prevalent in nature, and which probably favours the survival of those species that exhibit it.

Experiments in 1889.—These had two main objects, the first being to determine the amount of exposure to cold that could be borne in the different stages, the second to ascertain more definitely the effect upon the perfect insect of temperature conditions applied during the immature periods.

Under the first head it was found that the eggs of both species of *Selenia* were injured by protracted icing; a temperature of 80° to 90° F., on the other hand, did no harm and quickened their development. Some eggs of *S. tetralunaria* gave another good example of physiological dimorphism. Thirty eggs were iced for seventeen days. On their removal from the ice-box, two hatched at once; none of the rest yielded larvæ until from eleven to thirteen days afterwards, when nineteen of them also hatched.

Icing the larvæ of *S. tetralunaria* was found to be rapidly fatal, and cooling injurious. The older larvæ stood cold better than the young ones. Larvæ of *S. bilunaria*, *S. tetralunaria*, *E. autumnaria* and *E. alniaria*, L., all endured a continuous temperature of 80° F. or a little more without apparent injury; but one of 90° to 100° F. was very detrimental.

Further experiments showed that no harm resulted from icing for moderate periods the pupating larvæ and pupæ of *S. tetralunaria* and the pupæ of *E. alniaria*, nor from cooling to about 47° F. the pupating larvæ or pupæ of *E. autumnaria*.

Under the second head some interesting conclusions were arrived at with *E. autumnaria*, *E. alniaria* and *S. tetralunaria*. Eggs from a single pair of the first-named species were divided into batches, and larvæ and pupæ of each batch were brought up under carefully regulated conditions of temperature. The

same general result was obtained as in the 1888 experiments, but the additional fact was established that "it was in the pupal state that the effect was in the main produced. The forced pupæ, whatever the treatment of the larvæ had been, invariably produced pale and comparatively spotless moths; the cooled or iced pupæ, whatever the treatment of the larvæ had been, invariably produced dark and much spotted moths." It was found that a temperature of 63° F., or even higher, was low enough to produce the darker form. The treatment of the larvæ, though of slight effect compared with that of the pupæ, did not seem to be entirely without influence on the perfect insect; *e.g.* the specimens that had been forced only as pupæ were darker than those that had been forced all through. Some individual variation was noticed in all the groups. Similar experiments on *E. alniaria* gave results tending in the same direction, but less regular and striking.

The effects on *S. tetralunaria* were far more marked than in 1888. Pupæ of the summer brood were iced for periods successively increased by two weeks up to twenty weeks. These yielded moths becoming generally, but not regularly, more and more like those of the spring emergence, both in colour and pattern, as the period of icing was lengthened. The converse experiment of forcing pupæ of the autumn brood, which would naturally give rise to the spring form of the perfect insect, proved very injurious to the pupæ, the majority of which died even when the temperature was kept at 60° F. only. The moths that emerged were irregular in their time of appearing, and poor in condition. In colouring they were intermediate between the summer and spring forms, those that remained longest in the pupal stage being as a rule the darkest. This autumn spring brood, like the corresponding brood in *V. levana*, is evidently far more resistent in its colouring to temperature conditions than the summer one.

In all three species it was found that the period of pupation was longer for males than for females: most so in *E. alniaria*, least in *S. tetralunaria*.

The broods of *S. tetralunaria* that had fallen off in 1888 showed still further deterioration, both as to health and size, in the spring emergence of 1889. But some eggs of the degenerate race that were sent to Wimbledon produced once more much larger, more numerous and more healthy moths. The cause of this was apparently the change of condition, and especially the substitution of cherry for birch as the food plant.

As a result of this year's experiments, Mr. Merrifield came to the conclusion that the predisposition to assume one or other form in a seasonally dimorphic species can in some cases be completely controlled by external influences applied to egg or larva before the end of its growth; but not, except partially, after larval growth is finished.

Experiments in 1890.—In the course of 1890 the new fact was established that different portions of the pupal period were of different importance for the changes induced by temperature, and that the pattern or outline of the markings could be made to vary independently of the general colouring. It was proved to be possible to obtain by difference of treatment, from the same brood of a seasonally dimorphic species, individuals showing (1) summer markings with summer colouring, (2) summer markings with an approach towards spring colouring, (3) spring markings with summer colouring and (4) spring markings with almost the spring colouring.

A brood of spring larvæ of the light-coloured strain of *S. tetralunaria*, which would naturally have produced moths of the summer form, was forced as a whole; pupating in June. Some of the pupæ were kept at 80° F., these produced well-marked summer forms (Fig. 1). The rest were iced for about twelve weeks, and then either forced or put out of doors. Those that were forced after icing produced moths all of which had the summer colouring, and most of which showed the spring markings (Fig. 3). Some of these which were cooled at 43° F. after the colours of the wings had begun to appear under the forcing process, showed no difference from the rest. Those that were put out of doors after icing (temperature at 8 a.m. averaging about 57° F.) gave moths with the spring markings and a dark colour in some cases almost reaching that of the spring emergence (Fig. 4). Similar experiments on two other broods gave corresponding results, and showed that, in some instances, from two to three days forcing during the last part of the pupal stage might be enough to produce a very marked effect upon the colouring. Another brood, of the third generation, which fed up rapidly and pupated before the middle of August, gave rise at the ordinary temperature of the room (between 65° and 70° F.) to moths of the usual summer markings and colouring, but slightly darker than their forced parents. When twelve of these had emerged, the remaining pupæ were cooled at about 43° F. Those moths that emerged after twenty-six days cooling, while still showing the summer markings, presented an approach to the spring coloration (Fig. 2).

Some striking results were also obtained with *E. autumnaria*. Forcing the pupæ produced, as in 1889, pale and comparatively spotless moths (Fig. 5). When the pupæ were cooled for fourteen days or more before forcing, the ground colour became

FIG. 1.—*Selenia tetralunaria*. Summer markings and colouring. (Forced.)

FIG. 2.—*Selenia tetralunaria*. Summer markings, spring colouring. (Cooled.)

FIG. 3.—*Selenia tetralunaria*. Spring markings, summer colouring. (Iced, then forced.)

FIG. 4.—*Selenia tetralunaria*. Spring markings and colouring. (Iced.)

All the above were obtained from summer pupæ. Figs. 1, 3 and 4 are from the same parents. The difference should be noted in the shape of the inner area of the wings between Figs. 1 and 2 on the one hand, and Figs. 3 and 4 on the other.

dulled and the spotting blurred. Pupæ cooled for seven to twenty-eight days and then kept at the ordinary temperature of the room gave rise to moths as a rule very much darker than those finally forced; darker even than moths from pupæ that had been cooled for five or six weeks before forcing. The darkest moths of all were obtained from pupæ cooled for five or six weeks and then allowed to develop at the ordinary outdoor temperature, or this followed by cooling (Fig. 6). Even in these, forcing after eight days' exposure out of doors was found sufficient to counteract largely the tendency to darkening.

FIG. 5.—*Ennomos autumnaria*. (Forced.)

FIG. 6.—*Ennomos autumnaria*. (Iced.)

Both the above are from the same parents.

Experiments with *S. tetralunaria* and *E. autumnaria*, on the effect of moisture applied during the pupal stage in combination with various kinds of temperature, gave negative results.

A few trials of the effects of temperature on *Vanessa urticæ*, L. and *Lasiocampa quercus*, L., var. *callunæ*, were made this year, with the general result that cooling the pupa caused enlargement of the blue and dark marks in *V. urticæ*; while forcing the pupa caused increased paleness in *L. callunæ*, making it approach in aspect the ordinary *L. quercus*.

The suggestion was thrown out by Mr. Merrifield that the changes of pattern produced by temperature might assist investigators in tracing the evolution of the wing-markings in modern forms.

Experiments in 1891.—The first result established in 1891 was that the spring emergence of *S. tetralunaria* could be made by forcing during the penultimate pupal period to assume the colouring but not the markings of the summer form. In respect to the colouring it was found to be almost or quite as sensitive to temperature as the summer form, but in respect to markings it was completely resistent. The duration of the pupal period could in no case be shortened to that of the summer form; early and continued exposure of the winter pupa to a temperature of 80° F. or even of 60° F. generally proved fatal.

Experiments on the pupæ of both spring and summer broods of *S. lunaria*, Schiff., and *S. bilunaria*, and on the spring brood of *Falcaria falcataria*, L., gave the same general result of darkening in the cooled specimens and paling in the forced; and previous conclusions with regard to *S. tetralunaria* received confirmation.

In the case of *V. urticæ*, which was this year more completely investigated, it was found that a moderately low temperature generally deepened the colouring slightly, lowered the tone of the yellow patches, and spread the dark portions, especially the borders, enlarging also the marginal blue crescents.

Further experiments were also tried with *Lasiocampa quercus* and its variety *callunæ*. As in the former examples, exposure to a temperature of 80° F. was found to cause lightening, and to a temperature of 47° F. darkening, of the general ground colour. In *L. callunæ* the effect was most pronounced in the males. Some of the forced *callunæ* would, so far as regards colouring, be classed as *L. quercus*. *Arctia caja*, L., was found to be a species unusually intolerant of low temperatures, many pupæ dying when exposed to 50° or 60° F. In those that emerged there was a tendency for the dark spots on the hind-wings to spread and become confluent, and for the black transverse abdominal bars to increase in length and breadth. At 80° to 90° F. the brown of the fore-wings was paler than normal, and the red of the hind-wings took on a yellower shade.

The results obtained in this and former years seemed to Mr. Merrifield to afford evidence that besides the marking and coloration, the size and (less markedly) the shape of the wings might be affected by temperature. In most of the species tried the forced appeared to be smaller than the cooled specimens, and in the three species of *Selenia* a lengthening and increased angularity of the fore-wing seemed to result from a lowered temperature. In *V. urticæ* little difference was observed except in those from pupæ at 47° F., which were generally smaller than the others.

Temperature experiments on *Papilio machaon*, L., *P. podalirius*, L., (spring emergence), *Thais polyxena*, Schiff., *Argynnis paphia*, L., *Cerura vinula*, L., *Agrotis comes*, Hb., and *Attacus cynthia*, Drur. (all *winter* pupæ), gave negative results, as also did a careful trial of the possible effect of darkness and of different coloured light on *S. tetralunaria* and *A. cynthia*.

Experiments in 1892.—The experiments made this year were chiefly on butterflies; the first species taken being *Picris napi*, L. Pupæ of the summer brood were forced at 90° F. or kept at about 67° F. These yielded perfect insects of the ordinary summer form. Others of the same brood were iced for from three to four months; some were then exposed to an artificial "spring" temperature of 54° F., and the rest were forced at 80° F. Both of these two classes showed most of the characteristics of the usual spring form; *e.g.* on the upper surface greater suffusion and less intensity of dusky colouring; on the under surface faintness of the spots on the fore-wings and strongly marked nervures on all wings, with increased strength of the yellow parts. Those forced after freezing had the nervures more strongly marked than the rest, but in other respects partook less distinctly of the spring colouring. About one-fourth of the pupæ resisted attempts at forcing, and "went over" to the following spring, thus affording another instance of "physiological dimorphism."

A second species taken was *Vanessa atalanta*, L., which gave interesting results. About 100 pupæ were divided into six classes, and treated as under:—

(1) 80° to 90° F., emerging in 6 days.

(2) About 64° F., emerging in 18 or 19 days.

(3) About 56° F. (equable); emerging in about 34 days.

(4) 51° to 64° F. out of doors, averaging about 54°; emerging in 44 days.

(5) 45° to 58° F., averaging about 51°; emerging in about 40 to 50 days.

(6) 45° F. for from 32 to 47 days, then to various temperatures ranging from 90° F. (emerging in 6 days more) down to a mean of about 55° (emerging in from 19 to 34 days more).

Classes 2, 3 and 4 did not greatly differ among themselves or from the normal; their coloration, however, seemed on the whole to increase in intensity with the lowering of the temperature. In Class 1 the black ground-colour was slightly suffused with golden brown, the scarlet band was broadened, and its intensity of colour somewhat diminished. A new scarlet spot appeared on the under surface of the fore-wing (Fig. 9). In Class 5 the pale costal patch on the under surface of the hind-wing became more pronounced, and showed an increased tendency to spread along the costa. A light ochreous cloud about the middle of the hind margin of the same wing-surface, visible in normal specimens, became more strongly marked. In Class 6 the scarlet band was tinged with carmine, narrowed in area, and broken up by transverse bars of black. There was a tendency in the fore-wing to the diffusion of white and lavender scales over the black ground-colour, and round the edges of the white spots. The submarginal black spots of the hind-wing were often centred with lavender, occasionally a row of minute blue spots appeared in the margin of the dark portion of the hind-wing, and another on the extreme border of the wing itself (Fig. 10). On the under side there was more diffusion and blurring of markings, with an increased tendency towards the multiplication and spreading of pale areas.

FIG. 7.—*Chrysophanus phlæas*. (Diagrammatic.) Forced; showing large size of black spots on fore-wing, and diminished breadth of copper border on hind-wing.

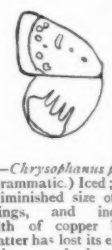

FIG. 8.—*Chrysophanus phlæas*. (Diagrammatic.) Iced; showing diminished size of black markings, and increased breadth of copper border. The latter has lost its external serrations, and shows prolongations passing inwards along the nervures.

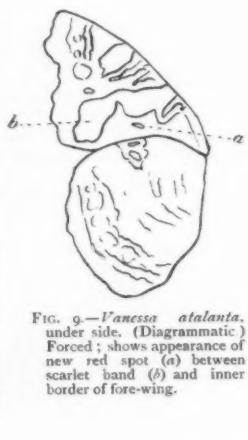

FIG. 9.—*Vanessa atalanta*, under side. (Diagrammatic.) Forced; shows appearance of new red spot (*a*) between scarlet band (*b*) and inner border of fore-wing.

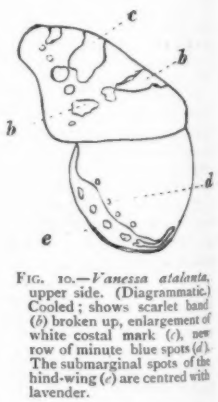

FIG. 10.—*Vanessa atalanta*, upper side. (Diagrammatic.) Cooled; shows scarlet band (*b*) broken up, enlargement of white costal mark (*c*), new row of minute blue spots (*d*). The submarginal spots of the hind-wing (*e*) are centred with lavender.

Chrysophanus phlæas, L., a species which had already been worked at by Weismann, was also made the subject of a series of temperature experiments. Well-marked differences were found to exist between the extreme forms produced under conditions of heat or of cold. The former caused enlarged size and diminished intensity of the black spots, a narrowing of the coppery band on the hind-wing, and a dusky suffusion of the fore-wings, especially towards the bases (Fig. 7). Under the latter, the black spots are much reduced in size, the coppery parts are lighter, and the coppery band on the hind-wing broadens, loses its posterior serrations, and often shows prolongations along the nervures towards the base (Fig. 8). These effects are

noteworthy inasmuch as they differ considerably from the results of heating and cooling in other species. Their peculiar relation to the temperature conditions is also remarkable; thus, summer pupæ kept at 33° F. for ten weeks, if afterwards allowed to remain at 55° F., gave the cold form in its extreme development; but if forced at 90°, gave the heat form almost as perfectly as those kept at 80° to 90° all through. Another curious point is that whereas a temperature of 47° F. was very injurious to the pupæ, they bore icing at 33° F. for ten weeks without damage.

Leucophthalmia punctaria, L., which was also tried during this year, gave results in some respects like the above. Thus, though forcing at 90° F. or icing at 33° were borne without injury, exposure to 45° proved harmful. Again, as in *C. phlæas*, "a temperature of 33° F. seemed to suspend the physiological changes without much other effect," for the pupæ exposed to this temperature for over three months, and afterwards forced, gave the heat form in almost as complete a state of development as those forced from the beginning. Summer pupæ were used for the experiment, and the general effect of cooling was to cause "gradual disappearance of the submarginal blotches, increase of dark sprinkling, and intensification of the central line as the temperature was lowered."

To Mr. Merrifield's account of his experiments during this year a short paper was appended by the present writer, giving reasons for considering certain of the modifications produced in *V. atalanta* by both heat and cold to be ancestral in character.[1] Some of the new features produced by heat were considered to show an approach towards *V. callirrhoe*, Hb., and some of those produced by cold appeared to indicate reversion to a still older form of *Vanessa*.

Experiments in 1893.—A number of winter pupæ of *Picris napi*, L., were divided into groups, some being forced in February and March, others left to emerge out of doors, which they did in late April and early May. The two divisions showed the same kind of difference, though in less degree, as was apparent in the summer brood of 1892 between those forced throughout and those cooled for the greater portion of their pupal period.

Experiments on both summer and winter pupæ of *Pararge egeria*, L., showed that the general effect of forcing was to lighten the ground colour and cause the pale spots to become smaller and less well defined. In no case was any approach shown to the bright ochreous colouring of the South European form.

In *Hydriomena silaceata*, Hb., cooling the summer pupæ caused an approach towards the usual colouring of the spring emergence; while forcing, besides producing a more uniform appearance, generally diminished the size of the perfect insect.

A trial was also made of the summer pupæ of *Araschnia levana*. The results were in general accordance with those previously obtained by Weismann; the effect of a raised temperature being to produce the dark *prorsa* form, and that of low temperatures (from 48° F. downwards) being to cause the appearance of the pure *levana* type, a few of those only exposed to moderately low temperatures showing slight traces of the intermediate *porima* colouring.

Interesting experiments were made on four species of *Vanessa*—*V. polychloros*, L., *V. atalanta*, L., *V. c-album*, L., and *V. io*, L. Pupæ of *V. antiopa*, L., gave negative results, probably in consequence of being already too far advanced when their treatment began.

In *V. polychloros*, high temperatures caused a general lightening of the ground colour and the appearance of yellowish clouds and streaks; the ordinary black spots were sharply defined. It was found that yellowish marks made their appearance to a greater or less extent when a temperature of 80° or upwards was employed, even if the pupæ had previously been cooled or iced for some weeks. When exposed to low temperatures, the pupæ produced perfect insects with a deeper and duller ground colour and a spreading of the dark marks, especially of the submarginal band. The enlargement of this band was always observed in cooled or iced specimens, whether subsequently forced or not. The whole ground-area was generally dusted with black scales, which tended to form new spots, especially in a row parallel to the outer margin in both fore- and hind-wing (Fig. 13).

Fresh experiments on *V. atalanta* confirmed the previous year's results and added new ones. Forcing temperatures up to 100° F. were employed, with the result of killing many of the pupæ. Those specimens that emerged showed a scarlet cloudy patch in that portion of the fore-wing which corresponds to the centre of the ocellus in *V. io*; and some of them showed another new scarlet spot on the under side of the fore-wing, in addition to the new spot observed in 1892. One of the apical white spots tended to be loosely ringed with scarlet in the forced, and with white in the cooled specimens. The latter were generally undersized.

In *V. c-album* it was found that both the first and second brood, but especially the first, became darker if exposed to a moderately low temperature.

Forced specimens of *V. io* showed a tendency to the development of dark spots near the apices of the nervular interspaces. Cooled and iced specimens showed a tendency, increasing as the temperature was lowered, for the dark costal "claw-mark" of the fore-wing to lose its regular curve and become angulated, for the apical pale spots to separate themselves more distinctly from the remains of the dark submarginal band, and for the bluish constituents of the ocellus in the hind-wing to divide themselves into two parallel series, a marginal and a submarginal. The resolution of the ocellus in the fore-wing was in one specimen very complete (Fig. 11).

A paper by the present writer drew attention to the further reversionary features disclosed by the temperature modifications

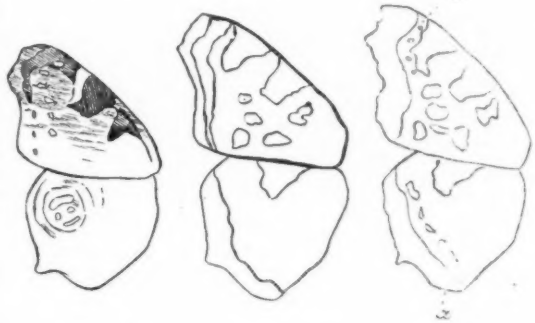

FIG. 11.—*Vanessa io*. (Diagrammatic.) Iced; showing resolution of ocellus.

FIG. 12.—*Vanessa polychloros*. (Diagrammatic.) Forced; shows size of black marks somewhat reduced. The yellow markings are not represented.

FIG. 13.—*Vanessa polychloros*. (Diagrammatic.) Iced shows tendency to formation of new submarginal row of black spots (*a*) in fore- and hind-wing.

above described, and commented on the significance of these phenomena with reference to the centripetal and centrifugal theories of heredity.

Experiments in 1894.—Pupæ of *Limenitis sibylla*, L., were found to be intolerant of heat. Those that survived a temperature of 85° to 90° F. gave rise to perfect insects with a slight increase of reddish scales near the apex of the fore-wings and the anal angle of the hind-wings. The orange-brown of the under surface was enlarged in area and paler in colouring. Exposure to a temperature of 48° F. for from three to five weeks caused a sprinkling of the white band with black scales, and on the under surface an increase in area and intensity of some of the darker parts with a tendency to suffusion and spreading of the white.

As a result of further experiments on *Vanessa c-album*, it was found that in certain of those exposed to low temperatures, which were not well borne by this species, there was an increase in the distinctness of the submarginal series of dark spots. Some of these were pupilled with bluish or lavender scales, as in the Chinese *V. c-aureum*, L., which appears to present an early form of the *Vanessa* pattern.

A few experiments were also made on *V. cardui*, L., giving results in accordance with those previously obtained by Standfuss in Zürich.

Experiments in 1895.—Both high and low temperatures (98° F. and 33° F.) were found to be well borne by pupæ of *Gonepteryx rhamni*, L. Little change was produced in the

[1] Weismann has expressed his general concurrence with these and subsequent conclusions of the present writer as to reversion (*Neue Versuche*, Jena, 1895, pp. 51, 72).

appearance of the imago, but the general effect of the low temperature was to reduce or abolish the orange discoidal spot on the fore-wing of both sexes, while under the high temperature the pale hue of the female appeared to assume a yellower tinge. In one instance this effect was well marked.

In *Vanessa atalanta* some further changes were observed as the result of high temperatures; the most remarkable of which were the appearance of a scarlet patch on the fore-wing between the red cross-band and the costa, and a long streak of grey-blue scales near the inner margin of the same wing. The most efficacious way of producing these modifications in this and other species of *Vanessa* appeared to be the use of a temperature of 95° F. to 102° F. for 12–14 hours at an early stage, afterwards gradually lowered, but still kept up to 85° F. or more till near emergence.

Some cooled specimens of *V. urticæ* bore great resemblance to the northern variety *polaris*. Heated specimens were like the southern form *ichnusa* in the shade and extent of the red ground colour, and also in the tendency towards disappearance of the isolated dark spots on the fore-wing. All three spots, however, were affected in these specimens, whereas in *ichnusa* the spot nearest the hind margin retains the normal appearance. Other changes were observed in the outer border, and in the shape of the fore-wing, the angulation being diminished.

Pupæ of *V. antiopa* at a low temperature gave similar results to those obtained with this species by Dr. Standfuss, but they were much less marked.

Experiments in 1896.—Pupæ of *P. daplidice*, L., from eggs laid in March, kept at a temperature of 70° F. to 80° F., gave the ordinary summer form. Some of the same batch, kept in the open air after five or six weeks' cooling at 52° F., emerged as the spring form *bellidice*. In *Melitæa didyma*, Esp., cooling at 51° F. was found to produce an extension of the black markings on the under side of the hind-wings. Of two specimens forced at 94° F., one was of an abnormally fiery tint.

Some specimens of *Saturnia pavonia*, L., from North Italy, forced in late winter and early spring, were much paler, ruddier and more uniformly coloured than those kept out of doors. This species is therefore not so resistent to temperature-conditions as many other winter pupæ.

Vanessa urticæ, var. *polaris*, from Lapland, was found to be sensitive to temperature, though less so than specimens from Central Europe.

Further experiments during the present year (1897) have shown that the tawny ground colour in *Argynnis paphia*, L., is brightened, and the size of the dark markings reduced by warmth, while the contrary effect follows exposure to cold. Also in *Aporia crataegi*, L., a low temperature causes much thickening and spreading of the black lines which mark the course of the nervures.

This ends the series of experiments so far undertaken and carried out by Mr. Merrifield. It is to be hoped that he will be able to continue and extend researches so interesting in themselves and so valuable to science. The present paper is concerned with facts only, not with their interpretation; but it must be obvious to any one who considers the remarkable results here briefly recorded, that they constitute an important contribution towards the better understanding of many disputed questions.

It may be well in conclusion to give Mr. Merrifield's own enumeration of the kinds of change observed. "The changes produced by temperature," he says, "are mainly of three kinds, viz. (1) general change, often striking, in the colouring, without material alteration in the pattern or form of the markings, but often with much enhancement or diminution in their intensity; (2) change caused by the substitution of scales of a different colour, either singly and generally distributed so as to be scattered, or so grouped as to cause a material change in pattern; (3) change in general appearance caused by imperfection in the development of scales or of their pigment. No. 1 seems a direct effect of temperature, not affecting vigorous development. Under No. 2 are to be ranged the most radical changes in pattern, as in the extreme case of *Araschnia levana-prorsa*, which have been explained on the theory of reversion to an earlier form. In No. 3 the wings are often somewhat reduced in size; the scales are scanty, irregularly placed, and often misshapen and deficient in pigment, the membrane of the wing showing between them. The three are more or less combined in many cases."

The figures which illustrate this paper were drawn from the plates which accompany Mr. Merrifield's papers in the Entomological Society of London's *Transactions*. F. A. DIXEY.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The Vice-Chancellor announces that he has opened a University Benefaction Fund, to which he has placed during the present term donations for various academic purposes amounting to nearly 3500*l*. This sum includes a gift of 1000*l*. from Dr. Peckover, Lord-Lieutenant of Cambridgeshire, and a grant of 1050*l*. from the Mercers' Company for the rebuilding of the medical schools. The family of the late Sir George M. Humphry, Professor of Surgery, have contributed 600*l*. towards the latter object, by way of a memorial gift; and Mr. H. Westwood Hoffman, 100*l*.

The Rede Lecturer for the ensuing year is Sir Henry Irving. Prof. Ewing, F.R.S., has been appointed Chairman of Examiners for the Mechanical Sciences Tripos. Mr. A. F. Stabb has been appointed University Lecturer in Midwifery.

The examinations in Sanitary Science will begin respectively on April 19 and April 26, 1898, the incidence of Easter having rendered the advertised dates inconvenient.

A scheme of theoretical and practical training has been organised for members of the University who are intending to become masters in public schools. The scheme is under the direction of the Teachers' Training Syndicate, and will be carried out in connection with the existing Day Training College. Certificates of efficiency will be granted to candidates who have pursued the prescribed course and passed the examinations of the Syndicate.

THE Council of the Institution of Civil Engineers have awarded a Salomons scholarship of 50*l*. to Mr. Edward Ernest Tasker, a student of the Technical College, Finsbury.

THE University of Upsala has received from Mr. Franz Kempe the sum of 150,000 knonor (about 8333*l*.) for an associate professorship of plant biology. Dr. Lundström has been nominated to occupy the chair.

SINCE the beginning of the academical half-year (states the *Lancet*) all students attending the chemical and physical laboratories of the University of Heidelberg have been insured against accidents happening in the course of the lectures, of the laboratory work, and of scientific excursions. The insurance premium is paid by the treasury of the University, which has also made a new regulation in connection with the subject requiring the students to pay a small sum in addition to the class fees.

A Fellowship to be called the Geoffrey Fellowship, of the value of 100*l*. a year for three years, has been presented to Newnham College, Cambridge, and will be awarded in June 1898. The Geoffrey Fellow will be required to reside at Newnham College, and to pursue independent study in some department of learning, letters or science. Candidates must be women who have obtained honours in a Cambridge Tripos Examination or in the Oxford Final Schools. They should send in their names to Mrs. Verrall, President of the Associates of Newnham College, before May 1, 1898. Each application should be accompanied by a statement of qualifications, a scheme of the work which the candidate proposes to carry out, and, if possible, a dissertation or other evidence of work done. Further information respecting conditions of tenure, &c., may be obtained from Mrs. Verrall, Newnham College, Cambridge.

SPEAKING at Northampton a few days ago, Lord Spencer urged that great efforts should be made to improve secondary education in England. Much had been done for education in the Victorian age, but it was absolutely necessary to fill the gaps existing between primary education and University education. He trusted that the measure which the Government would introduce would be satisfactory to all educationists, and he knew if it was it would have the support of even the opponents of the Government. One of the great difficulties in the way of carrying out technical education was the want of good secondary education. No more useful measure had been passed during the reign of the Queen than that giving county councils and borough councils grants for technical education, for it had stimulated a desire for secondary education and technical education. What was now wanted was a measure which would put technical education on something of the same basis, though not perhaps under the same supervision, as primary education. More aid was wanted from public funds and from rates. When they had that they would have attained something of great benefit to the

people of the country. Technical education was necessary. He was not one of those who could see for a moment that the prosperity of England was on the wane. But if England meant to keep her position in the commercial world she must not be behind with regard to the most important thing which had arisen in modern days connected with commerce—namely, the necessity of giving technical instruction to those who had to work in England's commercial market.

SCIENTIFIC SERIALS.

American Journal of Science, December.—A microsclerometer, for determining the hardness of minerals, by T. A. Jaggar. This instrument depends upon the energy required to make a boring of a certain diameter and depth under a given weight and by means of a diamond point of a cleavage tetrahedron of perfect shape. The hardness is measured by the number of turns required to make the boring, or by the depth reached after a certain number of revolutions. The depth is measured by a microscope attached to the boring point, by bringing successive divisions of a slanting micrometer scale into focus. The values found for the hardness of Mohs's scale-minerals show even greater gaps than those obtained by Pfaff and Rosival. Taking corundum as 1000, topaz is 152, quartz 40, orthoclase 25, apatite 1·23, fluorite 0·75, calcite 0·26, and gypsum 0·04.—On the sapphires from Montana, by G. F. Kunz. Sapphires were first found in transported gravels along the bars of the Upper Missouri, then in the earthy products of decomposed dikes, and lastly further down in the unaltered igneous rock itself. Much beautiful material has already been obtained, but little of high value.—On the corundum-bearing rock from Yogo Gulch, Montana, by L. V. Pirsson. The dikes of igneous rock containing sapphire and corundum are of a dark grey, basic appearance, and have an uneven fracture. In thin sections it appears as a dark lamprophyre, consisting mainly of biotite and pyroxene. There is a little iron ore present, but much less than is usually seen in rocks of this class.—Electrical measurements by alternating currents, by Henry A. Rowland. Gives some twenty-four methods of measuring inductances, capacities and resistances by means of alternating currents. Some of these depend upon a new principle in the shape of an adjustment of two currents to a phase difference of 90°. This is done by passing one current through the fixed, and the other through the suspended coil of an electrodynamometer. The fixed coil may then be made to carry a heavy current, and the sensitiveness of the apparatus is greatly increased. Inductances can be compared to within 1 in 10,000, but care must be taken not to twist the leads, as their electrostatic action is then very great. The question of standard inductances is thus practically solved.

THE latest issue of the *Izvestia* of the Russian Geographical Society is of exceptional interest. It contains, first, a brief sketch, by P. K. Kozloff, of the Roborovsky's Tibet expedition, in which the author dwells especially upon his own "excursions"—that is, the journeys which he made separately from the main body of the expedition, and gives very valuable data relative to the nature, and especially the animal world, of the visited regions. The reports about the journey in the Sy-chuan province, and to the Southern Kuku-nor ridge are especially interesting.—The geologist, E. E. Anert, contributes a very valuable sketch of his journeys in Manchuria. He started from the Suifun river, near Vladivostok, and went first to Ninguta, and then to Ghirin, the capital of Manchuria, where he took a boat and went down the Sungari till its junction with the Amur. The great Manchurian river, up to Ghirin, has been described already in 1864, by the expedition of Colonel Chernyaeff, who had with him the astronomer Usoltseff and P. Kropotkin; but the papers of these two explorers, which were printed in the *Memoirs* of the Siberian Geographical Society, were destroyed, as well as the original maps, during the Irkutsk conflagration, and remained almost quite unknown to geographers.—A third paper, of great interest, is by V. I. Lipsky, who was the leader of the Hissar expedition of 1896. Notwithstanding great difficulties, due to heavy snowfalls in winter, which were followed by heavy rains in spring, Lipsky explored the Hissar ridge from the south. The heights of the passes are from 12,000 to 14,000 feet. Ten new glaciers were discovered; they all lie above the 10,000 feet level, and are all surrounded by large moraines testifying to their previous larger extension.—The fourth paper is by Th. K. Drizhenko, who was at the head of a hydrographic expedition for the exploration of Lake Baikal in 1896. The paper is accompanied by a map of the lake showing the positions of the 100, 400 and 700 fathoms depth-lines, and another map showing the distribution of surface temperature during the month of August. The work of the expedition was continued this summer as well.—In the same issue G. V. Levitsky discusses the advisability of having a few seismic observatories in Siberia and Central Asia, each provided with a horizontal pendulum.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, December 9.—"On the Refractivities of Air, Oxygen, Nitrogen, Argon, Hydrogen, and Helium." By Prof. William Ramsay, LL.D., F.R.S., and Morris W. Travers, B.Sc.

In the course of an investigation on the nature of helium, many measurements of the refractivities of different samples were made with a view to determining their composition.

Since, on account of the great difference between the refractivities of air and helium, it was found inconvenient to compare the two gases directly, the helium was compared with hydrogen, and the refractivity of the hydrogen was afterwards determined with regard to air. As a check the hydrogen was subsequently compared with oxygen, and nitrogen free from argon, these gases were also measured against one another, and against air. At a later stage in the investigation the refractivities of argon and carbon dioxide were also determined.

The measurements were made by the interference method described by Lord Rayleigh (*Proc. Roy. Soc.*, 59, 198-208).

Special attention was paid to the purity of the gases examined, and a full description of the methods of preparation is given in the paper. It is possible that the discrepancies between the results obtained by various observers may be due to the presence of impurities in the gases which they employed.

The mean values obtained for the refractivities of the gases examined are tabulated below.

Refractivities of Gases, Air equal to Unity.

	Directly compared.	Through			
		Oxygen.	Nitrogen.	Hydrogen.	Argon.
Hydrogen ...	0·4733	0·4737	0·4727	—	—
Oxygen ...	0·9243	—	0·9247	0·9237	0·9261
Nitrogen ...	1·0163	1·0155	—	1·0170	1·0131
Argon	0·9596	0·9577	0·9572	—	—
Carbon dioxide	—	1·5316	—	—	—

Calculated from the determinations given above, assuming Dale and Gladstone's formula for mixtures of gases, the refractivity of air becomes 99·647 instead of 100.

Turning to the determinations of other investigators, it was found that since Dulong, in 1826, no single experimenter had made measurements of both oxygen and atmospheric nitrogen. Mascart determined the refractivity of nitrogen, and found it to be 1·0178, a value which closely agrees with the figure given above.

Lorenz determined the value for oxygen, 0·9347, but there is reason to doubt the purity of the gas which he employed. The refractivity of air calculated from the data of Mascart and Lorenz becomes 100·15.

Since the value obtained for the refractivity of air, calculated from the values obtained for oxygen, nitrogen and argon, differs from 100 by an amount far exceeding the limit of experimental error, we were driven to the conclusion that the refractivity of air is somewhat less than the refractivities of its constituents, taken in the proportion in which they occur.

It appeared advisable to try other mixtures; and a mixture of hydrogen and helium was first selected, because these are both very "perfect" gases, inasmuch as their critical points lie very low. It was to be expected that if a difference between calculated and found values should exist, it should be of the inverse character to that of a mixture of oxygen and nitrogen, for they are two somewhat "imperfect" gases. The result has borne out this idea.

A mixture was made of 20·60 c.c. of hydrogen and of 20·12 c.c. of helium free from argon, and of the density 1·960; and with the refractivity of the mixture those of hydrogen and

helium were compared. Taking the refractivity of the mixture as unity, the following ratios were found :—

Hydrogen/mixture ...	1·5977 1·5957	Mean ...	1·5967
Helium/mixture ...	0·4513 0·4478	,, ...	0·4495

The calculated values are—

$$\frac{(\cdot04495 \times 20\cdot12)}{40\cdot72} = 22\cdot21$$

$$\frac{(1\cdot5967 \times 20\cdot60)}{40\cdot72} = \frac{80\cdot87}{102\cdot99}.$$

Here the calculated value of the refractivity of the mixture is 3 per cent. higher than the found value, while with air the calculated value is 0·35 per cent. too low.

A third experiment was made, in which the "artificial air" was a mixture of 19·13 c.c. of carbon dioxide with 19·29 c.c. of oxygen, both gases supposed to be at 0° and 760 mm. Again, taking the refractivity of the mixture as unity we found the following ratios :—

Carbon dioxide/mixture	1·2450
Oxygen/mixture	0·7525

The calculated values are :—

$$\frac{(1\cdot2450 \times 19\cdot13)}{38\cdot42} = 61\cdot99.$$

$$\frac{(0\cdot7525 \times 19\cdot29)}{38\cdot42} = \frac{37\cdot78}{99\cdot77}$$

Here, as with air, the total refractivity found is less than that calculated. It is true the difference is not great, but we are persuaded that it is real, for it considerably exceeds the error of our several determinations.

The case is not bettered if Lorentz and Lorenz's formula be substituted for Gladstone and Dale's. Using their formula, $n^2 - 1/n^2 + 2$, the calculated result is 99·72 per cent. of that found for air.

The coefficient of compressibility of hydrogen is too small, while that of other gases, such as oxygen and nitrogen, is too great. The effect of mixing equal volumes of hydrogen and helium, each of which has too large a coefficient of elasticity, is to cause each to occupy twice the volume that they previously occupied, and to halve approximately the pressure for each. The pressure is, therefore, lower than it would be for an absolutely ideal gas, for each gas, hydrogen and helium. The sum of these pressures will accordingly be too low, or transposing, the sum of the volumes will be too great. The opposite argument holds for air.

Now, in considering volumes, we deal not merely with the co-volume, *i.e.* the space occupied by the molecules, but also with the interstitial space inhabited by the molecules. But the refractive power, if Clausius's deduction from the formula of Lorenz and Lorentz is correct, is a function of the dielectric constant, and hence of the co-volumes of the gases. And here the discrepancy is more easily detected than by any determination of density. It must, therefore, be concluded that gases are not, as postulated by Dalton, indifferent to one another's presence, but that they modify one another's properties in the same manner as do liquids, though to a different extent. This mutual action at high pressures and small volumes modifies even the volume relations, as recently shown by Dr. Kuenen. And it must persist at low pressures and large volumes, though it may not always be possible to make measurements of pressure and volume accurate enough to lead to its detection. The refractivity, however, seems to be a means delicate enough to be used for this purpose.

"The Electric Conductivity of Nitric Acid." By V. H. Veley, F.R.S., and J. J. Manley, Daubeny Curator of the Magdalen College Laboratory, Oxford.

In this paper an account is given of determinations of the electric conductivity of nitric acid of percentage strengths from 1·3 to 99·97, purified from nitrous acid, sulphuric acid and the halogen acids. Special forms of apparatus, and special methods of measurements were adopted to overcome the difficulties of polarisation of the concentrated acid.

The chemical and certain physical properties of the practically anhydrous acid were studied; this acid has no action on various metals such as copper, silver, cadmium, mercury, magnesium, iron and tin, nor on calcium carbonate either at ordinary temperatures or at the boiling point. Sulphur and iron pyrites dissolve quickly and completely in the gently-warmed acid. The values are given for the corrected density at 4/4, 14·2/4 and 24·2/4 of the 99·97 acid, as also for thirty-two samples of acid of $K_0 \times 10^8$, $K_{15} \times 10^8$, $K_{20} \times 10^8$, viz. conductivity in mercury units, and for $\alpha 10^4$, and $\beta 10^6$, the temperature coefficients in the equation $R_t = R_0 (1 - \alpha t + \beta t^2)$. It is shown that whereas nitric acid behaves as other electrolytes in possessing a positive temperature coefficient of conductivity for percentage strengths from 1·3 to 96·12, yet from this point upwards it behaves as a metallic conductor. The results of the experiments point to the existence of hydrates of nitric acid containing $10H_2O$, $3H_2O$, $2H_2O$ and H_2O, with one molecular proportion of HNO_3 and of $1H_2O$ with $2HNO_3$, or $H_4N_2O_7$, the analogue of pyrophosphoric acid. Evidence is thus added to that previously accumulated of definite combinations of nitric acid with water.

Chemical Society, December 2.—Prof. Dewar, President, in the chair.—The following papers were read :—The representation of the isomeric benzene hexachlorides by Collie's space-formula, by F. E. Matthews. The author shows that Collie's space-formula for benzene satisfactorily explains the existence of two benzene hexachlorides; amongst other facts explained are the different stability of the isomerides and the formation of only two.—Compounds of piperidine with phenols, by O. Rosenheim and P. Schidrowitz. A number of addition products of piperidine and phenols or their derivatives of a salt-like nature have been prepared in which the phenol acts as an acid; they are crystalline, and are decomposed by strong alkalis or acids.

Royal Meteorological Society, December 15.—Mr. E. Mawley, President, in the chair.—Mr. W. Marriott read a paper on the rainfall of Seathwaite, Cumberland. This place has long been noted for its heavy rainfall, being in fact one of the wettest spots in the British Isles—the average yearly amount is 137 inches. The spring months of April, May and June are the driest, so they not only have the least rainfall, but also the least number of rainy days. August, the month when the Lake District is thronged with visitors, has the greatest number of rainy days. The heavy nature of the rainfall may be gathered from the fact that 21 per cent. of the falls are above 1 inch, 2 per cent. being above 3 inches. The greatest fall in one day was 8·03 inches on November 12. The author has investigated the atmospheric conditions under which the heavy rainfalls occurred at Seathwaite, and he finds that these heavy falls are due to the direction and force of the wind. When the wind is blowing strongly from the south-east or south-west, it will be concentrated in the valleys on the windward of Scafell, and rush up them with considerable force, the air current consequently being projected to a considerable altitude beyond Scafell. Owing to the reduction of temperature with elevation, the air parts with a great deal of its moisture, which falls as rain. With such a process going on continuously for a whole day, the heavy rainfall at Seathwaite is fully accounted for.—Mr. R. C. Mossman also read a paper on the daily values of non-instrumental meteorological phenomena in London from 1763 to 1896. The phenomena discussed were thunderstorms, lightning without thunder, fog, snow, hail and gales.

CAMBRIDGE.

Philosophical Society, December 6.—Mr. F. Darwin, President, in the chair.—Features of interest in the fauna of the Sandwich Islands (with exhibitions), by Mr. R. C. L. Perkins. Mr. Perkins exhibited and read some notes on some of the more interesting insects from the Hawaiian Islands. Several species of endemic dragon-flies (*Agrionina*) were shown, some of which passed their earlier stages in water, in the usual manner, while others in the nymph state lived amongst the leaves of a liliaceous plant, the diversity in habit having probably been brought about by the extreme poverty of the freshwater fauna, the terrestrial species being much more favourably situated in regard to a constant supply of food. A series of examples of three or four allied species of Longicorn beetles of the genus *Plagithmysus* were remarkable for their extreme variability in colour, in spite of their limited range. The varieties of each species fell into two or three groups, which were hardly, if at all, connected by intermediate forms. The differences between the extreme forms of a species were in some cases more striking than the differences between the species themselves. The habits of these beetles, and the several distinct

sets of stridulating organs with which they are furnished, were also referred to. A collection of wasps from the islands of Molokai and Kauai were exhibited, to show the great difference in superficial appearance between those inhabiting the latter island, and those from the rest of the group. No protective significance could be attributed to the uniform and conspicuous markings of the Kauai species.—Remarks on a journey to investigate the habits and development of *Lepidosiren paradoxa*, by Mr. J. Graham Kerr. The author gave a short account of an expedition which he had made to the interior of the Gran Chaco of Paraguay for the purpose of investigating the habits and development of *Lepidosiren paradoxa*. He was aided by a grant from the Balfour Fund, and was accompanied by Mr. J. S. Budgett of Trinity College. Lepidosiren occurs in considerable quantity in the swamps towards the centre of the Gran Chaco boreal. It is sluggish in habits, wriggling slowly about among the thick vegetation of the swamp. At short but very irregular intervals it visits the surface and takes a breath of air. Its food consists mainly of large Ampullarias and masses of confervoid algæ. The young are to a greater extent vegetable feeders than are the adults. Lepidosiren makes a burrow in the ground at the bottom of the swamp, and lines it with soft grass. In this the eggs are laid. The papillæ on the hind limb of the male grow out into long filaments during the breeding season, and during life these are blood-red in colour. They appear to be ornamental structures. The eggs are very large—about 7 mm. in diameter. Cœlomic eggs have a thick gelatinous coat: in fertilised and developing eggs this becomes thin and horny. Segmentation is during its later stages holoblastic and unequal. Gastrulation takes place in a manner which recalls that of *Urodele amphibia*, and of Cyclostomes. Eventually a tadpole larva is hatched out. This develops large external gills and a very large sucker of the Amphibian type. The external gills and sucker disappear about six weeks after hatching. At the same time the colour of the young Lepidosiren becomes much darker, and they become much more lively in their habits. For the first ten to twelve weeks of its free existence the young Lepidosiren does not eat, but lives on the yolk in the walls of its gut. A remarkable habit of Lepidosiren was mentioned, in that their normally very dark colour becomes during the night nearly white. The black chromatophores shrink up during the hours of darkness, large yellow chromatophores which are also present remaining expanded. During the dry season the Lepidosiren retreats into the mud, in which it remains breathing by means of an air-hole until the waters return and set it free.

EDINBURGH.

Royal Society, December 6.—The following are the president and vice-presidents for the coming session:—Lord Kelvin; Lord McLaren, Rev. Prof. Flint, Prof. McKendrick, Prof. Chrystal, Sir Arthur Mitchell, and Sir William Turner. Papers were read as follows:—On the food, fuel, and air of the world, by Lord Kelvin.—Chapters on the mineralogy of Scotland, chapter viii., Silicates, by the late Prof. Heddle.—Note on the disturbance of the magnetic and meteorological instruments at the Colaba Observatory during the earthquake of June 12, 1897, by N. A. Moos.—On a problem of Sylvester's in elimination, by Prof. E. J. Nanson.—On the velocity of graded actions, by Prof. Walker.—Preliminary note on a characteristic of certain chemical reactions, by Prof. Gibson.—On the directions which are most altered by a homogeneous strain, by Prof. Tait.

Mathematical Society, December 10.—Mr. J. B. Clark, President, in the chair.—The following papers were read:—Some questions in arithmetic, by Prof. Steggall.—Methods of solution of the equations of elasticity, by Mr. John Dougall.—Trigonometrical notes, by Prof. John Jack.—Note on a transformation of the equations of hydrodynamics, by Mr. Carslaw.

PARIS.

Academy of Sciences, December 13.—M. A. Chatin in the chair.—The election of M. Ditte, as a Member in the Section of Chemistry, was confirmed by the President of the Republic.—On the work carried out in 1897 at the observatory at Mt. Blanc, by M. J. Janssen. The chief work done was on the value of the solar constant, although the observations were much interfered with by the unfavourable weather.—On the periods of double integrals, by M. H. Poincaré.—Signification of the number and symmetry of the fibro-vascular bundles of the petiole in the measurement of the perfection of plants, by M. Ad. Chatin.—On the first modifications of nerves in simple wounds of the cornea, by M. L. Ranvier. The nerve fibres of the cornea, which are divided by section, grow with an unexpected rapidity and activity, if they are in continuity with their origin cells.—Remarks, by M. Lœwy, on presentation of the annual publications of the Bureau des Longitudes.—On a new method for determining the vertical, by MM. J. Perchot and W. Ebert. The method of Deichmüller, floating a mirror in a bath of mercury, can be modified to give good results which are free from the prejudicial effects of capillary phenomena The results are as accurate as with the plain mercury bath, and good measurements can be obtained in Paris, where the amount of vibration renders the use of the plain bath very troublesome.—On the problem of Ribaucour, by M. C. Guichard.—On an analytical form of the integrals of linear partial differential equations of two independent variables, by M. J. Le Roux.—On the resolution of certain differential systems, by M. Riquier.—On a double generalisation of the equations of Lie, by M. E. Vessiot.—On the positions of unstable equilibrium, by M. P. Painlevé.—On the displacement of a plane of which all the points describe spherical lines, by M. Raoul Bricard.—The problem of the distribution of electricity and the problem of C. Neumann, by M. W. Stekloff.—New method of attacking platinum. Preparation of the bromoplatinates of ammonium and potassium, by M. Georges Méker. Platinum is attacked by a fused mixture of ammonium sulphate and bromide, although it resists the action of either salt taken separately. Ammonium bromoplatinate is readily isolated in a pure state from the fused mass.—On phosphorous oxide, by M. A. Besson. By warming together H_3PO_3 with an excess of PCl_3 on the water bath, and washing the product with water, a reddish solid is left, which on analysis gives exact figures for the oxide P_2O.—Properties of sodium carbide, by M. Camille Matignon. The carbide forms a white powder, not explosive by shock or by friction. On slight heating, it burns in air to sodium carbonate. In chemical activity, sodium acetylide far exceeds the corresponding calcium compound, nearly all the reactions being so violent that carbon is set free, and the sodium acting as in the free state.—On a new series of cyclic ketones, by M. A. Béhal. The fractional distillation of the heavy oil from wood tar, followed by conversion the benzoyl-oximes, has furnished two new ketones.—On the neutralisation of glycerophosphoric acid by alkalis, in presence of helianthine and phenolphthalein, by MM. H. Imbert and A. Astruc. The quantities of soda solution required to neutralise a given weight of glycerophosphoric acid in presence of helianthine and phenolphthalein respectively are as 1 : 2. A method for the estimation of the acid is worked out from these data.—Heat of neutralisation of glycerophosphoric acid, by MM. H. Imbert and G. Belugou.—New results relating to rachitis, by M. Œchsner de Coninck.—On species in botany, by M. Paul Parmentier—On polymorphism of branches in inflorescences, by M. H. Ricome. Branches of many inflorescences show differences among themselves. In branches in which the direction is near the vertical, the symmetry is normal. In branches much inclined to the vertical, this symmetry is more or less disturbed.—On the geology of the islands of Metelin, Lesbos, and Lemnos in the Ægean Sea, by M. L. De Launay.—On an apparatus generating leucocytes observed in the peritoneum, by M. J. J. Andeer. The peritoneum is the starting-point for the ostiolic apparatus of the whole animal. It is here shown that the peritoneum is also the starting-point for the genesis and formation of the elements of the blood.—Cholesterin and the biliary salts as a chemical vaccine against snake poison, by M. C. Phisalix. The bile salts exert the same protecting influence against snake poison as the bile itself.—On the entozoa of man in Normandy, by M. Ed. Spalikowski.

AMSTERDAM.

Royal Academy of Sciences, October 30.—Prof. van de Sande Bakhuyzen in the chair.—Prof. J. C. Kapteyn on the velocity with which the solar system moves in space. This velocity is deduced from the velocity in the line of sight of fifty-one stars measured by Vogel. It was demonstrated that from these velocities the sun's motion can be deduced with a weight more than seven times as great as that of the determination made by Vogel himself, if the ratio of the average velocity of the stars to that of the sun, previously communicated to the Academy, be made use of. Prof. Kapteyn found for the velocity of the system $10{\cdot}4 \pm 0{\cdot}7$ miles per second. From this, in connection with a previous communication, is further deduced the mean

parallax of stars of different magnitude.—Prof. Hubrecht presented for publication in the *Proceedings* a paper by Dr. G. C. J. Vosmaer, of Utrecht, entitled "On the retrograde development of the blood-vessels in the omentum of the rabbit," and showed by means of camera sketches of the omen of rabbits (new-born, one day, four days, eight days) that Ranvier's "cellules or réseaux vasoformatifs" are the last remnants of a process of retrograde development of vascular tissues in this membrane.—Prof. Bakhuis Roozeboom on an inquiry made by Dr. Mohr into the behaviour of solutions of $NH_4Cl + FeCl_3$, on crystallising out. Besides the well-known double salt $FeCl_3.2NH_4Cl.H_2O(D_1)$, there were detected: $FeCl_3.NH_4Cl(D_2)$ and $2FeCl_3.NH_4Cl.4H_2O(D_3)$. They were obtained by a new method of evaporation at a constant temperature in a desiccator under the microscope. Some solutions, which precipitate D_1 on evaporation, dissolve it again, when the evaporation is prolonged. The mixed crystals, which can also be precipitated from certain solutions, probably contain Fe as D_1.—On behalf of Dr. Cohen the speaker made a communication to the effect that the irregularities observed in the Weston-element (Clarke's, with the substitution of cadmium for zinc) had been found to be caused by a transformation which solid cadmium sulphate undergoes at 13°. It suffices to heat the element a little above this temperature to restore its normal behaviour.—Prof. van Bemmelen presented, on behalf of Dr. Klobbie, a paper on equilibrium in the water-ether, water-malonic acid and ether-malonic acid systems, and the isotherm of the water-ether-malonic acid system at 15°.—Prof. van der Waals communicated, on behalf of Dr. P. Zeeman, a third paper on doublets and triplets produced by external magnetic forces. Dr. Zeeman, working with a Rowland grating, has succeeded in photographing the outer components of the magnetic triplet, the light of the central component being quenched by means of a Nicol. The negatives obtained in this manner, and specimens of which were shown at the meeting, are particularly adapted for measurements concerning the magnetic change. Measurements of one of the blue cadmium lines have given for e/m the value 2, $4{\cdot}10^7$. The experiments are being continued.—His inquiries into the action of nitric acid upon methyl amides have occasioned Prof. Franchimont to study also the action of nitric acid upon methyl nitramines, and he has found that even below 0° nitrous oxide and methyl nitrate are formed nearly quantitatively, which is more easily deduced from the formula $CH_3.N{<}^{NOH}_{O}$ than from $CH_3.NH.NO_2$. Methyl nitramine does not produce blue, violet, or green colorations with ferric chloride, though under certain circumstances a reddish-brown ferric salt may be obtained from it. Prof. Franchimont further presented, on behalf of Mr. P. van Romburgh, a paper on the occurrence of certain volatile products in tropical plants. Mr. van Romburgh has already examined more than 900 genera and found methyl alcohol in many of them, acetone in some of them, but methyl salicylate in many more of them, viz. in 18 per cent. of the number examined. Sometimes it occurs together with prussic acid. The volatile reducing substance described by Reinke and Curtius was also often detected and obtained as a liquid from indigo, rameh, and the leaves of sugar-cane.—Prof. Lorentz on the question of the relative motion of the earth and the ether. Remarks on a recent memoir by Prof. A. A. Michelson (*Amer. Journ. of Science*, ser. 4, vol. iii. p. 475). The author discusses the assumptions that are necessary in the theory of aberration.—Prof. Stokvis presented the dissertations of Mr. J. Keyzer, entitled "Ueber Haematoporphyrin im Harn," and of Mr. J. de Hartogh, jun., entitled "Ueber Peptonurie und den Nachweis des Peptons im Harn," and added some oral elucidations.

NEW SOUTH WALES.

Royal Society, October 6.—The President, Henry Deane, in the chair.—Note on mutilations practised by Australian aborigines, by T. L. Bancroft. The paper dealt with the object of the "Mika" or "Kulpi" operation of the Australian aborigines.—On a cordierite-bearing rock from Broken Hill, by J. Collett Moulden. This is believed to be the first time that cordierite has been recorded in Australia. It has a somewhat extensive development in the metamorphic rocks of Broken Hill, and is described in detail from two parallel exposures of granulitic rock about half a mile S.E by E. from Block 14 Mine. The cordierite occurs in large crystals and also in grains through the granulite.—Note on the occurrence of a nickeliferous opal near Tamworth, N.S. Wales, by D. A. Porter. Several years ago a specimen of opal brought to the writer was said to have been obtained in the "Never-never" ranges on the head waters of Attunga Creek, and not far distant from Mount Gulligal, Parish of Attunga, County of Inglis. Some little while ago, being in the vicinity, Mr. Porter found the locality and secured a few small specimens, one of which he forwarded to be exhibited before this Society. The mineral occurs in the form of small veins in serpentine rock, and is accompanied by veins of a pinkish or salmon coloured chalcedony, exhibiting a porcelain-like texture and broken surfaces.—Icebergs in the Southern Ocean, No. 2, by H. C. Russell, C.M.G., F.R.S. This paper was prepared as a continuation of one read before the Royal Society, September 4, 1895. It deals with the reports of icebergs seen since the end of July 1895. One hundred and two ships have reported ice in the interval; nearly the whole of the ice, so reported, was within the area enclosed between 40° and 86° east longitude and 40° to 62° south latitude; very few reports of ice outside that area have been received. It was shown that the *Thermopylæ* steamed for 1000 miles amongst icebergs, and that the ocean was clear one hundred to one hundred and twenty miles north of this track. Some idea of the number of icebergs may be gathered from the fact that the officers of one ship counted 977 bergs, and those of another ship 4500. This and the previous paper cover a period of six years, and it was shown that at times the icebergs come into, or leave the track of vessels in a few days; three instances in which there had been sudden disappearances were shown to be coincident in point of time with the advent in Australia and the ocean between the Cape and Australia of strong north to north-west winds.

BOOKS RECEIVED.

Observational Astronomy: A. Mee, 2nd edition (Cardiff, *Western Mail*).—Annuaire Astronomique, 1898: C. Flammarion (Paris, E. Flammarion).—Catalogue of the Madreporarian Corals in the British Museum (Natural History): H. M. Bernard. Vol. 3 (London).—Annals of the Cape Observatory, Vols. 3, 6, 7 (Darling).—Ambroise Paré and his Times, 1510–1590; S. Paget (Putnam).—Model of a Locomotive: C. Volkert, translated (Philip).—26th Annual Report of the Local Government Board, 1896–97 (Eyre).—Solutions of the Exercises in Taylor's Euclid, Books vi.–xi.: W. W. Taylor (Cambridge University Press).—Elements of the Mathematical Theory of Electricity and Magnetism: Prof. J. J. Thomson, 2nd edition (Cambridge University Press).—The Steam Engine and other Heat Engines: Prof. J. A. Ewing, 2nd edition (Cambridge University Press).

CONTENTS.